Australasian Plant Conservation

Bulletin of the Australian Network for Plant Conservation Inc

Volume 29 Number 3 December 2020 – February 2021

Featuring articles on seed ecology, myrtle rust, orchid translocation, fern conservation and more!

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Front cover: *Pneumatopteris truncata* (foreground) in forest habitat. Photo: Alasdair Grigg, Christmas Island National Park staff

Printed by: Flash, Canberra.

Australasian Plant Conservation

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Australasian Plant Conservation is produced by the ANPC Inc. with assistance from the Australian National Botanic Gardens.

Australasian Plant Conservation is printed on recycled paper.

ISSN 1039–6500

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Australasian Plant Conservation is a forum for information exchange for all those involved in plant conservation: please use it to share your work with others. Articles, information snippets, details of new publications or research and diary dates are welcome. General articles on any plant conservation issue are most welcome.

The deadline for the autumn 2021 issue is 1 Feburary 2021. If you are intending to submit an article or wish to discuss possibilities, please email the editor, Heidi Zimmer: **editor@anpc.asn.au**.

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This issue

Regular features

From the editor

HEIDI ZIMMER

Summer is here and, thanks to La Nina, it feels very different to summer 12 months ago. In this summer edition of Australasian Plant Conservation we bring you stories of plant conservation from across Australia and even across the ditch – from our friends in New Zealand. Let's dive in.

We start out in Victoria, where Naomie Sunner *et al*. tell us of their work with the threatened daisy *Xerochrysum palustre* (Swamp Everlasting). While their surveys indicate some populations may have been lost – possibly outcompeted by tall graminoid species – they report some encouraging results on seed germination rates. This is followed by a short article by Ema Corro and Sapphire McMullan-Fisher, drawing attention to their search for native *Favolaschia* fungi – do get in touch with the authors if you think you might be able to help.

In the next section we move to case studies for the ANPC's Germplasm Guidelines currently under revision, and to be published in the middle of 2021. First, we travel to south-east NSW to an article by Stig Pederson which focuses on Myrtle Rust, its impact on *Rhodamnia rubescens* (Scrub Turpentine) and the collaborative effort from the south-east NSW Bioregion Working Group to conserve this species. Next, Noushka Reiter *et al*. introduce us to the Royal Botanic Gardens Victoria Orchid Conservation Program's *ex situ* collection, and their work on orchid pollinator identification. Then, in a second article by Reiter, we learn about the successful conservation translocation of the Endangered *Caladenia colorata* (Colourful Spider-orchid) at four sites – these introduced populations are now considered self-sustaining. In the fourth Germplasm Guidelines case study we head to Christmas Island to learn about a Critically Endangered fern *Pneumatopteris truncata*. Caroline Chong *et al*. describe their efforts in *ex situ* conservation of this species, through germination of spores, to propagation and cultivation and establishment of an *ex situ* population. Learnings from this study will be informative for *ex situ* conservation of ferns worldwide. James Wood, in the fifth Germplasm Guidelines case study, describes his success in using dry heat shock treatments to break physical dormancy in Tasmanian *Pomaderris* species, detailing methods which other practitioners will no doubt find useful. In the last of the Germplasm Guidelines case studies for this issue we head across to New Zealand, where Karin van der Walt describes cryopreservation options for the fleshy-fruited *Syzyguim maire* which, like *Rhodamnia rubescens*, is threatened by Myrtle Rust. She finds that exposure to Plant Vitrification Solution (PVS2, which is key to cryopreservation) for more than 30 minutes negatively impacted embryo viability and suggests methods which will limit exposure to PVS2.

We round out the issue with our regular features: Australian Seed Bank Partnership (ASBP) news, a profile of Stanthorpe Rare Wildflower Consortium – our new community group ANPC member, a book review, ANPC news and research round up. Enjoy!

Exploring seed ecology and habitat of the vulnerable Swamp Everlasting – *Xerochrysum palustre*

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Introduction

Xerochrysum palustre (Flann) R. J. Bayer, (Swamp Everlasting, Asteraceae) is a rhizomatous, perennial herb of swamps and seasonal wetlands endemic to south-eastern Australia. It is listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* because of threats such as disruption to hydrology, weed invasion and road and rail developments. The 2011 National Recovery Plan (Carter and Walsh 2011) states that only 35 populations are known, with all of these occurring in NSW, Victoria and Tasmania, with many populations estimated to consist of less than 250 plants. As a clonal species, determining an accurate population size is difficult (Carter and Walsh 2011). A seemingly large population may only represent a few genetic individuals and may not produce viable seed (Young *et al.* 2002). Minimum population size for maintaining genetic diversity and reproductive success for *X. palustre* is not known, however as many related species from the Asteraceae are self-incompatible, reproductive success of *X. palustre* may be significantly reduced in small populations if genetic variability declines (Morgan *et al.* 2013).

Specifically, we addressed three key aims which are in-line with the 2011 recovery plan: 1) to assess the number, size and area of *X. palustre* populations; 2) to identify germination and thermal thresholds of *X. palustre* seed; and 3) elucidate any habitat characteristics of *X. palustre* to determine relationships between neighbouring species and flowering individuals of *X. palustre*.

Figure 1. *Xerochrysum palustre* in flower at Gisborne Racecourse Marshlands Reserve. Photo: N. Sunner, 2019

Methods

Site selection and surveys

Survey sites were chosen using known *Xerochrysum palustre* locations as recorded in the Atlas of Living Australia (2018) and subsequent conversations with ecologists and land managers who were familiar with the species. Seven sites, many within the Melbourne metropolitan area (Table 1) were surveyed between November 2018 and January 2019 to assess whether the *X. palustre* populations were still present, and to determine the extent and size of these populations. Given the difficulty of approximating population size and density of clonal species such as *X. palustre*, a method was adapted from Cropper (1993). Two 50 m transects were placed across populations randomly, and flowerheads were counted within every 1 m^2 quadrat along the transect line. To determine if neighbouring plants compete with *X. palustre* by reducing the number of flower heads in each quadrat, we measured the height of the tallest non-*X. palustre* species growing in each 1 m^2 quadrat along the transect line.

Seed selection

Seeds of *X. palustre* were either collected *in situ* over the 2018/2019 summer season or obtained from donated *ex situ* collections (see Table 1). Seed was collected from three populations during site surveys from flowerheads along transect lines and opportunistically throughout

populations. One of the sites, Gisborne Racecourse Marshlands Reserve, is dissected by the Calder freeway for approximately 50 m, therefore each side of the freeway was treated as a different site.

Germination testing

In order to determine the germination niche of the species (the breadth of temperatures under which germination is possible), we used a Temperature Gradient Plate (TGP, Model GRD1, Grant Instruments, Cambridge, UK) which provides a gradient of temperatures from approximately 5 to 40°C. On a 12-hour diurnal light cycle, two replicate 35 mm petri dishes from each seed lot with 1 % agar solution were arranged on the TPG in a stratified random manner, spread across the range of temperatures on the plate. There were 10 seeds per petri dish of each seed-lot collected over the summer of 2018/2019, and five seeds per petri dish from accessions supplied by the three herbaria. Signs of germination (defined as emergence of the radicle) were recorded five times per week in the first two weeks, and then weekly thereafter for two weeks.

Variation in germination rates between sites was analysed with an ANOVA using Tukeys method for pairwise comparisons using Minitab 18. Correlation between height of associated graminoid species and flowering individuals of *X. palustre* was analysed using linear regression with Minitab 18.

Results

Site surveys

Of the seven populations surveyed in 2019, *Xerochrysum palustre* was located at only three, however it was subsequently found in low numbers the summer of 2019/2020 at Manks Road, Clyde after the conclusion of this study (Michael Longmore, pers. comm).

Table 1. Sites surveyed for presence of *Xerochrysum palustre* with the last recorded sighting on the ALA (2018) and seeds donated from herbaria used in germination experiment. Seedlot codes BEV = Beveridge, C33 = CANB879733, C34 = CANB879734, DOL = Doling Doling, GNTH = Gisborne North, GSTH = Gisborne South, M22 = MEL2280849, T15 = TSCC0015741, T18 = TSCC0011825.

Site	Last ALA sighting /date of seed collection	Latitude/longitude	Seedlot code (blank if no *X. palustre* found to be seeding)	Present in summer of 2018/2019
Beveridge-Wallan Rail Reserve, Wallan, Victoria	June 2014 / December 2018	-37.431051, 145.002596	BEV	Yes
Cranbourne Wetlands Nature Conservation Reserve, Cranbourne, Victoria	January 2010	-38.0641, 145.2531		No
Doling Doling Swamp Lake Reserve, Hamilton, Victoria	December 2010 / December 2018	-37.70517804, 142.078418	DOL	Yes
Gisborne Racecourse Marshlands Reserve, New Gisborne, Victoria – supplied by National Herbarium of Victoria and collected in December 2018	December 2014 / December 2018	-37.46987798, 144.590717	GNTH and GSTH, M22	Yes
Healesville Freeway Reserve, Bayswater North, Victoria	January 2006	-37.8219, 145.2847		No
Lal Lal Rail Reserve, Lal Lal, Victoria	November 2008	-37.6747, 144.0125		No
South Gippsland Rail Reserve, Manks Road, Clyde, Victoria	December 2005	-38.1705, 145.3716		No – but found in summer of 2019/2020
South East Forest National Park, New Line Road, Tantawangalo, NSW – supplied by Australian National Herbaium	13th March 2015	-36.765, 149.4381	C34	
Roadside swamp 9.8 km east of Cathcart on Pambula road (Mt Darragh Road), NSW – supplied by Australian National Herbarium	13th March 2015	-36.8425, 149.4914	C33	
Smiths Lagoon, Cleveland, Tasmania – supplied by Tasmanian Herbarium	21st January 2010	-41.81044, 147.42342	T18	
Bronte Lagoon, Bradys Lake, Tasmania – supplied by Tasmanian Herbarium	28th February 2012	-42.20811, 146.48319	T15	

Table 2. Population area, number of flowerheads and density of flowerheads at sites where *X. palustre* was present.

Site	Population area	Density of flowerheads per m²	Estimated number of flowerheads in population
Beveridge	250–290 m²	3.27	817–948
Doling Doling	8,000–12,000 m²	1.43	11,440–17,160
Gisborne North	160,000–180,000 m²	6.33	1,012,800–1,139,400
Gisborne South	20,000–25,000 m²	9.52	190,400–238,000

The three populations where *Xerochrysum palustre* was located varied greatly in population size and density. Both Gisborne populations were large and had a high density of flowerheads per square metre, while the Beveridge and Doling Doling populations were smaller in area with a low density of flowerheads (Table 2).

As the height of graminoid species co-occurring with *X. palustre* increased, the average number of flower heads decreased (Figure 2). However, regression analysis found this trend to be statistically insignificant.

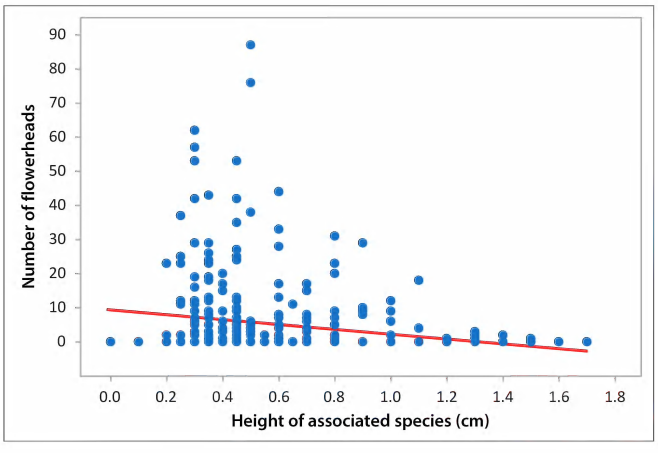

Figure 2. Height of associated graminoid species vs number of flowerheads in each 1 m² quadrat (blue circles), with regression line (red).

Germination results

Xerochrysum palustre germinated across a wide temperature range exhibiting ≥ 80% germination between 15–28.5°C (Figure 3). Unsurprisingly, germination was recorded at lower temperatures over longer periods; for example at 8°C 60% of seed germinated after 29 days. Above 28.5°C germination declined rapidly: 50% at 36.5°C, 10% at 38.5° C and no germination at 41° C. All populations (seedlots) had good germination in the optimum range of 15–28.5°C (Figure 3). The two seedlots with the lowest germination were from Beveridge and Doling Doling (Figure 4). The Doling Doling seedlot was found to have statistically significant lower germination than all other seedlots with the exception of Beveridge (P <0.01).

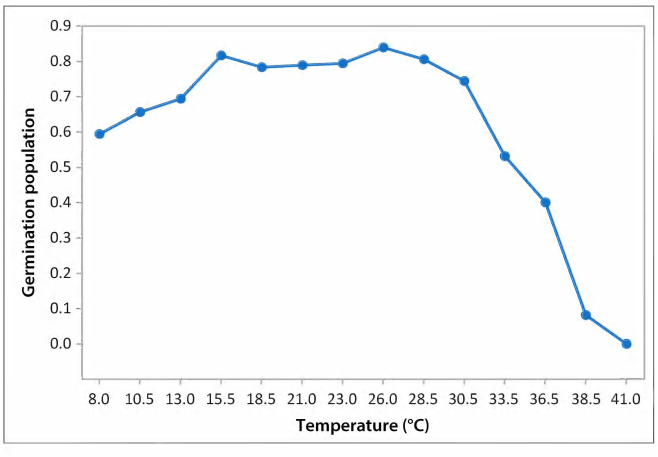

Figure 3. The proportion of germination of all *X. palustre* seedlots across a temperature range recorded on Day 29.

Discussion

All populations of *Xerochrysum palustre* used in this study produced viable seed with high and rapid germination rates across a wide range of temperatures, indicating no discernible seed dormancy. This demonstrates *X. palustre* could recruit from seed throughout most of the year across its range. However, the seed from the two populations with lower flower density, Doling Doling and Beveridge, germinated at significantly lower rates.

The number and extent of populations of *X. palustre* is in decline, with three populations unable to be found less than a decade after the National Recovery Plan was implemented. At these three sites, large areas of dense indigenous graminoid species were observed, namely *Lepidosperma longitudinale, Baumea rubiginosa, Eleocharis acuta* and *Phragmites australis*. Interestingly, within the *X. palustre* sites, *X. palustre* often absent where dense patches of tall graminoid species were growing. The species was located and flowering in vehicle tracks or in areas where the dense sedge had been flattened by resting kangaroos. The observations in this study suggest *X. palustre* was less likely to be flowering or indeed present in areas with tall graminoid species, which suggests biomass management at sites is important for species persistence.

Further work incorporating population genetics could assist this vulnerable species, providing an assessment on genetic variation and population size. In addition, further study into the effects of competition with neighbouring species could assist land managers with appropriate management regimes, such as fire management and weed control, to facilitate recruitment across sites.

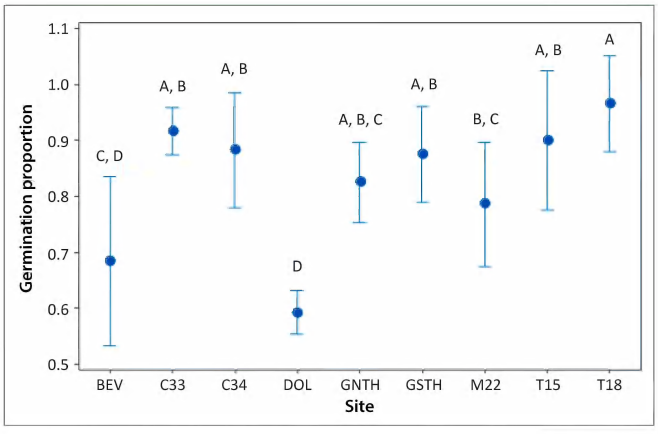

Figure 4. The proportion of germination of seeds incubated at temperatures ranging between 15–28°C by seedlot. Error bars show standard deviation for germination within each seedlot; BEV = Beveridge, C33 = CANB879733, C34 = CANB879734, DOL = Doling Doling, GNTH = Gisborne North, GSTH = Gisborne South, M22 = MEL2280849, T15 = TSCC0015741, T18 = TSCC0011825. Means that do not share a letter are significantly different.

Acknowledgements

Seed was collected under permit number 10007717 for the Royal Botanic Garden Melbourne. Thanks to Tom North of the Australian National Herbarium, the National Herbarium of Victoria and James Wood of the Tasmanian Herbarium for their generous provision of seed for germination trials. A number of ecologists and land managers provided helpful information on the species, including Karl Just, Graeme Lorimer, Brian Bainbridge, Michael Longmore, Damien Cook, Vanessa Craigie and Richard Francis. Thanks also to Parks Victoria and Vic Track for access and information on sites. Emily Newling provided technical support with the temperature gradient plate in the laboratory at Deakin University.

References

Atlas of Living Australia (2018). '*Xerochrysum palustre*.' Available at https://bie.ala.org.au/species/http://id.biodiversity.org.au/node/apni/2890165 [Accessed 25 July 2018].

Carter, O. and Walsh, N. (2011). *National Recovery Plan for the Swamp Everlasting* Xerochrysum palustre. Melbourne.

Cropper, S.C. (1993). *Management of Endangered Plants*. CSIRO, Melbourne.

Morgan, J.W., Meyer, M.J. and Young, A.G. (2013). Severe habitat fragmentation leads to declines in genetic variation, mate availability, and reproductive success in small populations of a once-common Australian grassland daisy. *International Journal of Plants Sciences* 174: 1209-1218.

Young, A.G., Hill, J.H., Murray, B.G. and Peakall, R. (2002). Breeding system, genetic diversity and clonal structure in the sub-alpine forb *Rutidosis leiolepis* F. Muell. (Asteraceae). *Biological Conservation* 106: 71-78.

Searching for native Favolaschia

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*Favolaschia calocer*a is an invasive 'weedy' wood decomposing fungus that has been spreading rapidly in Australia since the 1990's. It is a threat to the diversity of indigenous fungi as it inhabits a broad range of substrates from twigs up to large logs. It also out competes native wood rotting fungi that help with nutrient cycling. It is able to live in the canopy of wetter forests, so airborne spores can spread widely and away from paths. It has spread across much of southeast Queensland, southwest WA, and eastern Victoria. There are isolated patches in NSW and northern Tasmania. Importantly, there are national parks and areas it so far hasn't reached. For example, there have been no reported sightings in the Wombat Forest or the Grampians in Victoria. Hygiene to prevent spread into new conservation areas is important. Recently MYCOmmunity (http://myco.org.au) have developed a LAMP test (loop mediated amplification) to detect *Favolaschia* DNA in the environment, which is specific to *Favolaschia*. We are hoping that this test can be used to monitor and slow its spread. In particular we would like to see if it is being moved around by equipment such as council mulchers. We need help getting samples of native *Favolaschia* species to make sure that the test is specific to *Favolaschia calocera*.

Please check out our website if you can help us or want to know more. http://myco.org.au/tracking-the-invasive-orange-ping-pong-bats-fungus/

Native Favolaschia. Photo: SJM McMullan-Fisher

***Favolaschia calocera* spreading spores in the canopy in Springbook, SEQ in 2011. Photo: SJM McMullan-Fisher**

Rusted on and fired up: a collaborative effort to save the Scrub Turpentine

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Background

South East NSW is host to a handful of predominantly Australian native botanic gardens and until recently not much, if any, collaboration took place between them. But around six years ago the initiative was taken to form a collaborative network between those gardens, a network to become known as the SE NSW Bioregion Working Group. The group was established predominantly as a means to further plant conservation in SE NSW. The founding members include the Australian Botanic Garden Mount Annan (ABGMA), the Australian National Botanic Gardens (ANBG), Wollongong Botanic Gardens (WBG), Eurobodalla Regional Botanic Gardens (ERBG) and the Booderee Botanic Gardens (BBG). The then NSW Office of Environment and Heritage (OEH), and Grevillea Park at Bulli soon joined the group. Recently the Shoalhaven Heads Native Botanic Garden too has become part of the group.

The Group has successfully worked on a number of projects over the past few years, with a conservation effort directed at the Scrub Turpentine (*Rhodamnia rubescens*) now underway, and described in this article.

Booderee rescue

The Scrub Turpentine is one of several hundred species in the Myrtaceae family which is affected by Myrtle Rust (*Austropuccinia psidii*). Scrub Turpentine is a medium-sized tree which occurs naturally in and around rainforest margins in coastal areas north from Batemans Bay in NSW through to Bundaberg in Qld. It was until a few years ago thought of as just another common plant species, but the emergence of Myrtle Rust in 2010 has now brought it to the forefront of plant conservation. It has, along with three other species, recently been listed as Critically Endangered in NSW due to Myrtle Rust causing a rapid decline in health and vigour, often leading to death. Field observations over the past few years have generally been depressing; foliage deformed and sparse, and seed set almost never observed. Trees which on previous site visits were alive will on following visits turn out to be dead; as experienced at Booderee National Park three years ago. The species was known to occur naturally at two locations in the Park and had been monitored regularly since Myrtle Rust was first observed on individual trees in approximately 2012.

In 2017, on-site inspections found one of the two populations to be completely dead. A stand of maybe 20 trees had gone from being somewhat affected by the rust, to having kicked up their heels within just 12 months. This instigated a rapid and targeted emergency action by the Booderee National Park and Botanic Gardens. Plant material was collected and propagated with the aim to establish an *ex situ* collection of the remaining population, in case those plants too should perish. Pleasantly, this was achieved with four plants subsequently established at the BBG nursery. The near Booderee extinction got staff thinking: what was happening beyond Booderee and the NSW South Coast? It was known, from talking to colleagues in the industry, that such events were commonplace throughout the species' range, but what was being done to address the rapid decline? We understood the OEH was working hard to address the situation, but lack of funding seemed to be an issue. The following year, 2018, saw publication of the draft action plan on Myrtle Rust in Australia, but again, there was no funding to go with it. It was then that Booderee and other members of the SE NSW Bioregion Working Group decided to act.

Gene pooling

The Group has always had extensive experience in propagation and horticultural maintenance, and it seemed obvious that we could address one of the actions out of the Myrtle Rust plan: germplasm capture. The alternative was to sit on our hands and watch the wild populations disappear without having at least tried. We weren't willing to accept that. The ERBG at Batemans Bay and the BBG at Jervis Bay are both conveniently located to access the very southern extent of the species, and it seemed only natural for the two partners to get directly involved. We teamed up with ex NSW NPWS officer Phil Craven, who from previous employment had vast knowledge of the area, so it was with confidence we entered Murramarang National Park in June 2019. A number of sites were visited but the general health of plants wasn't good, with various degrees of Myrtle Rust visible at all sites. However, we collected cuttings from no less than eight different locations, in the hope propagation might succeed despite the less than perfect material. A further two sites in the Tomerong area, close to Jervis Bay, were later visited and cuttings collected.

As a matter of caution, all material was divided equally between the two botanic gardens, in efforts to mitigate unforeseen threats and failures at either garden. To our great pleasure more than 50 cuttings at Booderee struck roots after a few months, and Eurobodalla likewise had good success (Figure 1). Importantly we now had *ex situ* plants representing every one of the 10 sites we had sampled from.

Fire

Enter December 2019; ferocious fires were burning throughout most of Australia's east coast, and it was now time for the NSW South Coast to bear the brunt. We soon learned that fire, known as the Currowan Fire, had hit the Murramarang National Park and burnt most of the sites we had visited only six months earlier. And further disaster struck; New Year's Eve 2019 was one of the worst fire days on the South Coast, not least for the ERBG. The Gardens were completely overrun resulting in much infrastructure and most of their living collections being lost, including Scrub Turpentines in the nursery. Only three small plants survived. 10 months later, and with limited access still in place for the Murramarang National Park, it is difficult to get a full picture of the fire's impact on the species. Only two small trees, on a site previously occupied by in excess of 100 plants, have been observed with epicormic growth (Figure 2).

Figure 1. *Rhodamnia rubescens* cuttings at the Booderee Botanic Gardens' propagation facilities. Photo: Stig Pedersen

Ex situ pays dividends

Having set out to create an *ex situ* conservation collection due to the Myrtle Rust threat, it seems a good dose of luck had played into our hands. Had we not collected plant material before the fires; had we not collected from the southern extent of the species; and had we not shared plant material, it is quite possible a sizeable gene pool would have been lost for good. As it is, the BBG is currently the only place where it can be said with certainty that genetic material is available.

Figure 2. *Rhodamnia rubescens* at Murramarang National Park with epicormic growth in October 2020 following December 2019 fires. Photo: David Cunningham

Now and into the future

A second round of propagation from nursery stock is proving successful this spring. In addition, the nursery stock flowered well this winter resulting in good fruit set (Figure 3). Further work this winter had us team up with NSW conservation officers and the WBG, this time collecting cuttings between Nowra and Austinmer, north of Wollongong (Figure 4). Provided the latest propagation efforts prove fruitful we will now have *ex situ* collections representing plants from 15–18 sites between Sydney and Batemans Bay. All the while liaising with partners with the aim to share plants and seeds to further secure the southern extent, as we await developments on action plans and funding.

Figure 3. Fruiting *Rhodamnia rubescens* at the Booderee Botanic Gardens' nursery. Photo: Stig Pedersen

Figure 4. Collecting *Rhodamnia rubescens* at Austinmer, winter 2020. Photo: Julianne Noble

Acknowledgements

Phil Craven. Formerly NSW National Parks and Wildlife Service. David Cunningham. NSW National Parks and Wildlife Service.

References

Makinson, R.O. (2018). *Myrtle Rust reviewed: the impacts of the invasive pathogen* Austropuccinia psidii *on the Australian environment*. Plant Biosecurity Cooperative Research Centre, Canberra.

Makinson, R.O., Pegg, G.S. and Carnegie, A.J. (2020). *Myrtle Rust in Australia – a National Action Plan*. Australian Plant Biosecurity Science Foundation, Canberra, Australia.

NSW Government Department of Planning, Industry and Environment (2020). Available at: https://www.environment.nsw.gov.au/threatenedspeciesapp/speciesbytype.aspx

Saving orchids from extinction: the RBGV Orchid Conservation Program *ex situ* collection

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Introduction

Australia has over 1800 species of orchids, most of which are terrestrial. Orchids are overrepresented on Australia's threatened species list, making up 17% of all nationally listed flora (~197 species). The Royal Botanic Gardens Victoria (RBGV) Orchid Conservation Program aims to prevent extinction by:

- Storing a diverse representation of seed and mycorrhizal fungi.
- Propagating suitable numbers of each of our threatened orchids.
- Undertaking conservation translocations of these species to protected public and private land where the appropriate vegetation, climate conditions and pollinator(s) are present.

The RBGV Orchid Conservation Program undertakes research on all aspects of orchid ecology, including pollination, mycorrhizal associations, propagation, demographics and translocation. For south-eastern Australian orchids, the RBGV Orchid Conservation Program has established a permanent *ex situ* collection of seed, mycorrhizal fungi and living plants propagated from seed.

For each species, plants have been hand-pollinated and the seed collected. With the assistance of volunteers, seed is cleaned, dried at 15% relative humidity (RH) for two weeks, and stored in sealed airtight packages at -20°C. The *ex situ* seed collection now includes diverse seed collections from over 150 orchid species and well over 2,500 accessions of seed. For each species of orchid, we also isolate the mycorrhizal fungi and store pure cultures permanently *ex situ* at -80°C for use in propagation and molecular identification. The RBGV now have over 3,000 isolates of mycorrhizal fungi stored at -80°C for use in future conservation introductions and for taxonomic studies into their identity, ecology and distribution.

Since 2014 the RBGV has grown a large *ex situ* collection of orchids for conservation, introduction and education, which is based at the Cranbourne site. Seeds are germinated symbiotically with their mycorrhizal fungi in the laboratory and grown on in flasks before being potted up in the nursery. This *ex situ* living plant conservation nursery now consists of over 20,000 plants from 165 species of orchid, including 68 state and nationally threatened species. These species are primarily from the genera *Caladenia*, *Diuris*, *Thelymitra*, *Pterostylis* and *Prasophyllum*. A dedicated group of volunteers assist research staff in the curation and management of the collection. This collection holds many species brought back from the brink of extinction including *Caladenia pumila*, *Thelymitra mackibbinii*, *Caladenia audasii*, *Diuris fragrantissima* and *Prasophyllum correctum*.

This *ex situ* collection is now used extensively for seed orcharding of threatened orchids, pollination studies, taxonomy and conservation introductions. To date this *ex situ* collection of orchids has contributed to well over 50 introductions of threatened orchids across south eastern Australia.

Here we give two examples of *ex situ* collections leading to conservation outcomes. *Caladenia arenaria* is an Endangered species, endemic to the Riverina of southern New South Wales. *Caladenia versicolor* was formerly widespread across Victoria and South Australia and is now extinct in South Australia and is known from two populations with less than 600 individuals in total.

Propagation

Mycorrhiza were isolated as per the methods of Reiter *et al.* (2020a). Fungal cultures had DNA extracted, sequenced and identified as per Reiter *et al.* (2020a). The mycorrhizal fungi were identified as *Serendipita* OTU A (Reiter *et al.*, 2020a) for both species and did not vary between the remaining sites of this species. Plants were grown symbiotically with their mycorrhizal fungi, from seed to mature flowering individuals using the techniques of Reiter *et al.* (2016).

Pollinator baiting

Baiting trials were undertaken using the baiting method of Reiter *et al.* (2018). These are summarised here for clarity. Potted plants (20–30 flowers) grown from seed symbiotically from the *ex situ* collection of each of our study species were used for baiting. Using large numbers of flowers increases the stimulus perceived by pollinators for food deceptive or food rewarding species.

Observations of the pollinators were made during the flowering period of wild populations of the orchids. A selection of insects visiting or pollinating the bait flowers were collected for identification.

Conservation translocation

Translocation data is only presented for *C. versicolor*, as *C. arenaria* is due to be translocated by project partners in 2021. Plants grown symbiotically were translocated into *de novo* (new) sites that were permanently reserved by Trust for Nature. The size of intact native vegetation of the translocation sites in size was chosen as > 100 hectares of suitable vegetation that matched that of the extant sites. Each site had the pollinator present (Reiter *et al.* 2019; 2020a). Each individual orchid was planted with a permanent marker, 10 cm to the north to aid in re-emergence monitoring and identification of the plants in subsequent years. Each plant was caged and watered (up to monthly average rainfall only if rainfall fell below average) for the first season only, until plants entered their first dormancy in the field. Between 2013 and 2017, 798 plants were planted of *C. versicolor*.

Monitoring

All plants were monitored annually for emergence (July), flowering (September-November) and seed set (November-December). In addition, any recruits were recorded. Each species also had one wild population monitored using this method for comparison against the translocation sites.

Results

Caladenia versicolor

The pollinator was identified as *Leioproctus maculatus* (Reiter *et al.* 2019) a small colletid bee with the orchid providing a meagre food reward. The pollinator was identified at two of the remaining wild sites and the introduction sites. Over 1,000 plants have been propagated symbiotically with *Serendipita* OTU A for an *ex situ* collection and introduction. Seed orcharding has begun on the *ex situ* collection to ensure that adequate seed is available for future conservation work with this species. For the introduced plants grown symbiotically from seed there was 88% survival, 47% flowering, 30% pollination as of July 2019. The first signs of recruitment were in 2017; and the total number of recruits recorded on the introduction sites thus far is > 60. Emergence on the wild site of the species was 81%.

Caladenia arenaria

Caladenia arenaria was found to have at least two pollinator species (Reiter *et al.* 2020b), the thynnine wasps *Tachynomyia* sp. nr *volatilis* and *Aelothynnus westwoodii.* Both of these species removed and deposited pollinia, and were found at suitable translocation sites that matched the vegetation characteristics of existing orchid populations (Reiter *et al.* 2020b). Approximately 2,000 individuals have been cultivated symbiotically with *Serendipita* OTUA from seed from the three largest remaining populations of this species. These plants await introduction into the selected sites in 2021 with project partners. Seed orcharding has begun on the *ex situ* collection to ensure that adequate seed is available for future conservation work with this species.

Figure 1. Examples of *ex situ* living collections at RBGV grown from seed with their mycorrhizal fungi and now flowering in the shade house; *Caladenia cretacea* and *C. cruciformis*. Photo: Richard Dimon, RBGV

Acknowledgements

RBGV Orchid Conservation Volunteers Charles Young, Bryan Lawrence, Mike Wicks, Eve Almond, Peter Wallace, Neil Freestone, Neil Anderton, Lynda Entwisle, Wendy Bedggood, Gail Pollard, nursery technician Chris Jenek and assistance of the Australasian Native Orchid Society volunteers in planting translocation sites. I would like to thank my co-authors of the pollination papers and the various organisations that support this program including the NSW Government's Saving our Species program, the Wimmera CMA and DELWP. A full list of funding bodies can be found at https://www.rbg.vic.gov.au/science/projects/orchid-conservation

References

Reiter, N., Phillips, R. D., Swarts, N., Wright, M., Holmes, G., Sussmilch, F., Davis, B., Whitehead, M. and Linde, C. (2020a). Specific genus-wide mycorrhizal associations in *Caladenia* (Orchidaceae); Fungal sharing between common and threatened orchids. *Annals of Botany* 126: 943-955.

Reiter, N., Bohman, B., Freestone, M., Brown, G.R. and Phillips, R.D. (2020b). Pollination by nectar-foraging thynnine wasps in the endangered *Caladenia arenaria* and *Caladenia concolor* (Orchidaceae). *Australian Journal of Botany* 67: 490-500.

Reiter, N., Bohman, B., Batley, M. and Phillips, R.D. (2019). Pollination of an endangered *Caladenia* species (Orchidaceae) by nectar-foraging behaviour of a widespread species of colletid bee. *Botanical Journal of the Linnean Society* 189: 83-98.

Reiter, N., Bohman, B., Flematti, G.R. and Phillips, R.D. (2018). Pollination by nectar-foraging thynnine wasps: evidence of a new specialized pollination system for Australian orchids. *Botanical Journal of the Linnean Society* 188: 327-337.

Reiter, N., Whitfield, J., Pollard, G., Bedggood, W., Argall, M., Dixon, K., Davis, B. and Swarts, N. (2016). Orchid re-introductions: an evaluation of success and ecological considerations using key comparative studies from Australia. *Plant Ecology* 217: 1-15.

Conservation Translocation of the endangered Colourful Spider-orchid (*Caladenia colorata*)

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Abstract

Caladenia colorata D.L.Jones is an endemic endangered species from south eastern Australia. 883 plants were symbiotically propagated and translocated into four sites within one property where the pollinator was present, and the vegetation matched wild sites. Demographic monitoring showed an 80% survival of translocated plants with natural pollination and fruit set. In addition, 580 seedlings recruited across these sites, with natural pollination and seed set of the seedling recruits first recorded in 2019. Introduced populations are now considered self-sustaining, with these conservation translocations increasing the total number of *C. colorata* in the wild by 1,286 plants.

Introduction

The Royal Botanic Gardens Victoria Orchid Conservation Program is working with over 30 nationally threatened orchid species conducting conservation research on their propagation, pollinator identity and distribution, mycorrhizal associations and translocation. *Caladenia colorata* is given here as an example of the species we are working to conserve, that incorporates the pollinators and mycorrhizal fungi in the conservation translocation program. *Caladenia colorata* is endemic to south eastern Australia where it is now known from a handful of populations in South Australia and Victoria in and surrounding the Little Desert National Park. The species is listed as nationally Endangered (EPBC Act, 1999). The total number of wild plants is thought to be less than 600 plants with pressures from grazing and weed invasion. *Caladenia colorata* typically has one to three flowers that range in colour from pale yellow to pink or yellow with a red lip (Figure 1).

Methods

Propagation

Thirty plants from across two wild populations of *C. colorata* were hand pollinated, using pollen from flowers greater than 10 m apart from each other. Seeds were collected four-six weeks after pollination. Seed was cleaned and dried to 15% relative humidity before being stored short term at 4°C, over silica until further use. Mycorrhiza were isolated as per the methods of Reiter *et al.* (2020). Fungal cultures had DNA extracted, sequenced and identified as per Reiter *et al.* (2020).

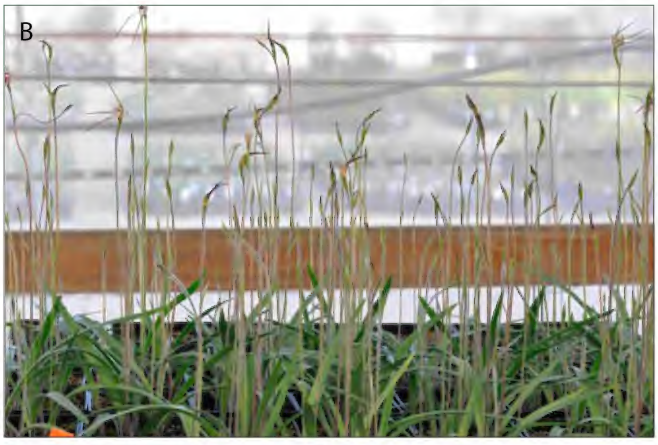

Figure 1. A) *Caladenia colorata* flowering (pink form), B) *C. colorata* grown in nursery and C) *C. colorata* translocation seedling recruits as marked by red dot. Photos: N. Reiter

Plants were grown symbiotically with their mycorrhizal fungi, from seed to mature flowering individuals using the techniques of Reiter *et al.* (2016).

Pollinator baiting

Baiting trials were undertaken using the baiting method of Reiter *et al.* (2018). Potted plants grown from seed (as described above) of *C. colorata* were used for baiting for the presence of the pollinator. Observations of the pollinators were made during the flowering period of wild populations of the orchid. A selection of thynnine wasps from each site were identified using a series of unpublished keys to the *Australian thynnine* wasp fauna (G Brown, unpubl. data).

Site selection

Introduction sites were selected that were greater than 100 hectares, had a vegetation and soil match to extant sites of *C. colorata*, were permanently protected land tenure and had the pollinator present. In addition, each site was fenced with rabbit proof fencing and any weed or herbivore control was undertaken on each site as required.

Plants were translocated into sites where *C. colorata* had not previously been known to occur that were covenanted through Trust for Nature.

Each individual orchid was planted with a permanent marker, number and tag 10 cm to the north to aid in re-emergence monitoring and identification of the plants in subsequent years. The location of each plant was triangulated in the field again to aid future detection. Each plant was caged and watered (up to monthly average rainfall only if rainfall fell below average) for the first season only, until plants entered their first dormancy in the field. Between 2013 and 2017, 883 plants were introduced of *C. colorata*.

Monitoring

All translocated plants of *C. colorata* were monitored annually for emergence (July), flowering (September-November) and seed set (November-December). In addition, any recruits were recorded. A wild population was also monitored using this method for comparison against the translocation sites.

Results

The mycorrhizal fungi were identified as *Serendipita* Operational Taxonomic Unit A (Reiter *et al.* 2020) and did not vary between the remaining wild sites of this species. Over 1,000 plants were propagated symbiotically for introduction and as a permanent *ex situ* collection. Seed orcharding has begun on the *ex situ* collection to ensure that adequate seed is available for future conservation work with this species.

The pollinator was identified as the thynnine wasp species *Phymatothynous pygidialis* which removed and deposited pollinia (Reiter *et al.* 2018). The pollinator was present at both the remaining wild sites in Victoria and the introduction sites (Reiter *et al.* 2018).

Of the 883 plants that were introduced between 2013 and 2017, 80% survived with an additional 580 recruits. The control wild population had on average 83% emergence +/- 18% SE.

Discussion

Successful large-scale conservation translocations are underpinned by matching suitable habitat, ensuring that translocation sites are weed and predator free and permanently protected. This alongside an understanding of both the mycorrhizal and pollinator associations (Phillips *et al.* 2020), and large founder populations (Silcock *et al.* 2019) has ensured the success of translocations of *C. colorata*.

This research highlights the importance of *ex situ* collections to facilitate research into pollinators and their distribution. This *ex situ* collection allowed large quantities of seed to be banked for future conservation, and permanent *ex situ* collections of living plants have been developed. Introductions of endangered orchids on a large scale incorporating knowledge of both the pollinators and mycorrhizal fungi is both possible and can provide significant conservation outcomes for threatened species. These conservation translocations have more than doubled the number of wild plants of this species, with substantial natural recruitment seen. Indeed, the introduced populations are now self-sustaining with a population growth rate >1, within 7 years of starting conservation translocations. This is faster than our prediction of up to 15 years (Reiter *et al.* 2016).

Acknowledgements

Thank you to Sam and Sari Cuci, Len and Josie Carrigan, Wendy Bedggood, Mary Argall, volunteers of the Australasian Native Orchid Society Vic Branch, my co-authors on published papers of the pollination and mycorrhizal associations of this species and to Richard Dimon and Ilham Kurnia Abywijaya for assistance with monitoring in 2019.

References

Phillips, R.D., Reiter, N. and Peakall, R. (2020). Orchid conservation: from theory to practice. *Annals of Botany* 126: 345-362.

Reiter, N., Whitfield, J., Pollard, G., Bedggood, W., Argall, M., Dixon, K., Davis, B. and Swarts, N. (2016). Orchid re-introductions: an evaluation of success and ecological considerations using key comparative studies from Australia. *Plant Ecology* 217: 1-15.

Reiter, N., Bohman, B., Flematti, G.R. and Phillips, R.D. (2018). Pollination by nectar-foraging thynnine wasps: evidence of a new specialized pollination system for Australian orchids. *Botanical Journal of the Linnean Society* 188: 327-337.

Reiter, N., Phillips, R. D., Swarts, N., Wright, M., Holmes, G., Sussmilch, F., Davis, B., Whitehead, M. and Linde, C. (2020). Specific genus-wide mycorrhizal associations in *Caladenia* (Orchidaceae); Fungal sharing between common and threatened orchids. *Annals of Botany* 126: 943-955.

Silcock, J.L., Simmons, C.L., Monks, L., Dillon, R., Reiter, N., Jusaitis, M., Vesk, P., Byrne, M. and Coates, D.J. (2019). Threatened plant translocation in Australia: a review. *Biological Conservation* 236: 211-222.

Ex situ conservation of a critically endangered fern

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Summary

Pneumatopteris truncata is listed as Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Australian population occurs only on Christmas Island where fewer than 50 mature individuals are known and population size fluctuates significantly across years. *Ex situ* conservation was prioritised as a critical response to insure against loss of the wild population. Spore from wild subpopulations was collected and germination and propagation techniques were trialled. This work has established *ex situ* spore and plant collections (more than 100 plants), developed protocols for germination and propagation of this species and identified priority future research for threatened fern species.

Introduction

The fern *Pneumatopteris truncata*

Although *P. truncata* occurs across Indonesia and South East Asia, the Australian regional population is confined to Christmas Island, a geographically isolated island in the north-east Indian Ocean (off Western Australia). Here, the taxon is known as the Dales Waterfall fern and occurs as three subpopulations across two locations, including The Dales Ramsar site (Butcher and Hale 2010; Figure 1a). The large, erect fern has fronds to 120 cm and occurs only within closed forest where springs create permanently wet limestone habitat (Figure 1b).

Current and potential threats

The small population size (total number of mature individuals) provided the basis for listing the species as Critically Endangered in 2004 (Threatened Species Scientific Committee 2004; Butcher and Hale 2010). Surveys conducted throughout the late 1980s, 2002 and 2003 recorded only 45 mature individuals at two subpopulations (Holmes and Holmes 2002). Disturbances such as cyclone damage to canopy cover negatively impact the population.

Figure 1a. Location of the Hughs Dale and Andersons Dale subpopulations of *Pneumatopteris truncata* on Christmas Island, Indian Ocean.

Figure 1b. *Pneumatopteris truncata* (foreground) in forest habitat. Photo: Alasdair Grigg, Christmas Island National Park staff

In situ management

Since 2010 Parks Australia has conducted annual subpopulation monitoring at Hughs Dale. Monitoring at this site has identified extreme fluctuations in the number of individuals present (juvenile and mature), ranging between 0 to 500 individuals across years with the proportion of juvenile plants typically exceeding 80% (A. Grigg, 2020). A comparison of the number of individuals per year with annual precipitation indicates that larger numbers of individuals may be positively associated with above-average rainfall and declines associated with dry years (Figure 2).

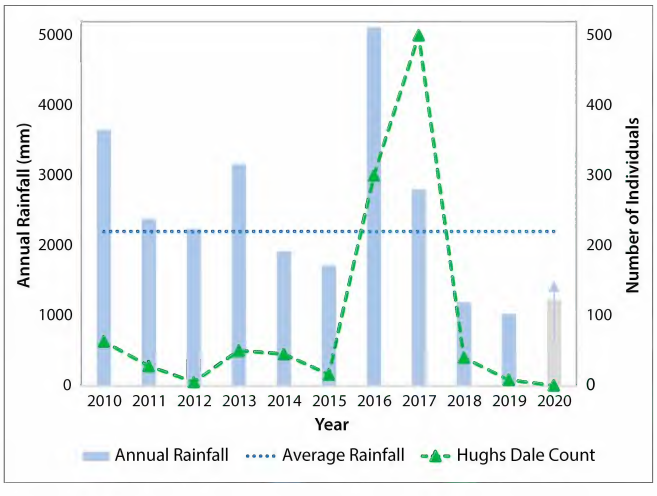

Figure 2. Number of individuals of *Pneumatopteris truncata* recorded at the Hughs Dale subpopulation from 2010 to 2020 (green line), annual rainfall (mm) (blue solid bars); average rainfall (mm) (blue dashed line).

Methods – *ex situ* conservation

Pneumatopteris truncata was prioritised for *ex situ* conservation on the basis of threats, observed population fluctuations and cost-benefit ranking (Di Fonzo *et al.* 2017).

Spore collection

Spore collecting occurred in March 2018, closely following the monsoon season. Collecting aimed to maximise genetic representativeness without placing stress on the population. Whole fronds greater than 1 m bearing mature sporangia were collected from 16 individuals and placed into large paper bags. Collected fronds were kept at ambient temperature for 2–3 days until spore release. Spore was then transferred into paper envelopes and kept separate as maternal lines. To facilitate spore drying, spore collections were maintained at ambient temperature and approximately 50% relative humidity (RH) for approximately 3 weeks before transport and storage in the dark at 5°C.

Germination trial

A germination trial was conducted eight months after spore collection at the Australian National Botanic Gardens (ANBG). Four germination media were tested: 1) milled sphagnum moss (saturated with purified water), 2) 70:30 mix of peat moss and sand (saturated with purified water), 3) 0.7% water agar (pH 6-7), 4) alkaline 0.7% water agar (pH 8.0, 1 M HEPES biological buffer). All media (150 mL per replicate) and containers (90 mm diameter plastic lidded containers) were sterilised in an autoclave (Tomy ES315) and water adjusted to establish a thin film of water on the media surface. Four replicates of 15 maternal lines on 4 media types were trialled with 2 mg of spore hand sown in each container and sealed with parafilm. Containers were stored in incubators at 25°C and a 12/12 hr light/dark photoperiod with light intensity maintained by LED strip lights at 970 lumens per metre.

Containers were monitored fortnightly for germination and contamination. Spore germination was recorded by placing a 1 cm^2 grid across each container and counting the number of grid cells containing green prothalli and/or sporophyte plants. The percentage of grid cells containing germinated spores at 10 weeks was arcsine transformed and analysed by ANOVA in Genstat (VSN International 2020).

Propagation and cultivation

Germinants on agar were transferred to sphagnum moss either 74 or 112 days after the germination trial began. Once all germinants were transferred to sphagnum moss, the plants were moved to a propagation house at approximately 20°C, 95% RH under a hood and on capillary matting. Container lids were incrementally removed, and holes pierced in the bottom of containers to introduce gas exchange and water flow gradually over two weeks to prevent shock. The sporophytes showed signs of nutrient deficiency (chlorosis), which was addressed with fortnightly applications of Hortico All Purpose Soluble fertiliser at a rate of 0.5 grams per 500ml of water (boiled and cooled). Between seven and nine months after the germination trial began, sporophytes were potted into 70 mm pots containing plugger 666 growing medium (Australian Growing Supplies) avoiding root disturbance. At this stage a single application of Multicrop Plant Starter at 24 mL per 9 litres of water was supplied.

Results

Germination trial

Germination was successful from eight-month-old spore from 15 maternal lines from two subpopulations (Figure 3a, 3b). Of the four media types, germination was only observed on water agar and sphagnum. Time to first observed germination (prothalli) was four weeks after sowing on 0.7% water agar, while germination on sphagnum moss was first observed at six weeks. Germination media significantly affected both the total germination ($P < 0.001$) and the rate of spore germination ($P < 0.001$; Table 1). Total spore germination varied with maternal line ($P = 0.003$). Contamination in some agar containers after six weeks killed some germinants, which resulted in reduced total germination (Figure 3a).

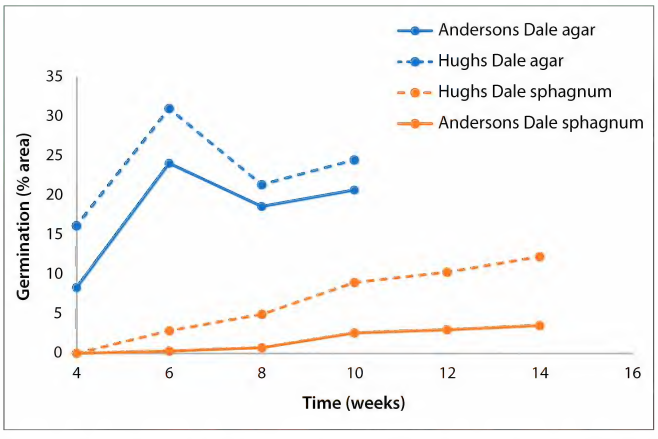

Figure 3a. Observed germination of *Pneumatopteris truncata* from two subpopulations (Andersons Dale, Hughs Dale) on water agar and sphagnum moss. X-axis values are time (number of weeks) since spore sowing. Germinants on agar were transferred to sphagnum from 6 weeks following observed germination.

Propagation and cultivation

Although germination was generally five times higher on agar than sphagnum moss, subsequent transfer shock associated with movement to sphagnum growing medium caused many germinants to die. Germinants from both agar and sphagnum dishes were transferred to pots and grown at approximately 20°C and 95% RH where they grew equally as vigorously regardless of germination medium.

Propagation and cultivation efforts resulted in 52 plants from 3 maternal lines from the Hughs Dale subpopulation and 51 plants from 5 maternal lines from the Anderson Dale subpopulation, totalling 103 plants established and maintained at the Australian National Botanic Gardens (Figure 3c).

Figure 3b. Successful growth of sporophyte plants at 11 weeks following transfer to sphagnum moss from agar and c. 5 months from observed germination. Photo: Fanny Karouta-Manasse

Discussion

We developed protocols for short-term storage, germination and propagation to establish an *ex situ* population and provide information to guide conservation and research efforts for *Pneumatopteris truncata*. Such *ex situ* techniques may be suitable to conserve other fern species. We found that *P. truncata* spore, if collected when mature and dried appropriately, can be stored at 5°C and less than 70% RH for at least eight months. Germination was greatest in spore sown on water agar, but relative survival was greatest from spore sown on sphagnum moss, potentially due to minimal root disturbance during transfer. Plants grow well in standard potting media and benefit from consistent water and nutrient availability. Cultivation conditions with temperatures between 20°C to 30°C and RH greater than 80% produced healthy growing plants.

Figure 3c. Potted ferns of *Pneumatopteris truncata* growing at the Australian National Botanic Gardens nursery 9 months after spore germination. Photo: Fanny Karouta-Manasse

Table 1. Summary analysis of variance of *Pneumatopteris truncata* spore germination. Significant sources of variation in bold.

	Final % germination			Days to first germination		
Source of variation	d.f.	v.r.	F pr.	d.f.	v.r.	F pr.
Germination media	3	87.48	**< 0.001**	1	321.30	**< 0.001**
Maternal line	15	4.62	**0.003**	15	2.21	0.012

The living conservation collection of *P. truncata* plants at the ANBG may represent a greater than doubling the number of individuals in Australia once they reach reproductive maturity. These plants and spores secured at conservation facilities are useful resources to evaluate, under controlled conditions, the environmental requirements for growth and survival to inform potential future augmentation of wild populations.

Future trials at the Christmas Island nursery will aim to understand the environmental thresholds for plant growth and survival. Laboratory trials will aim to understand spore longevity and requirements for effective long term *ex situ* spore conservation, including through assessing spore desiccation tolerance and chilling sensitivity.

Acknowledgements

Roslan Sani, Leonard Stapp, Ian Shepherd and Heather Sweet for invaluable field assistance; Sally Hawkins, Fanny Karouta and Julie Percival for germination and propagation trial assistance; Sue Fyfe, David Taylor, Judy West and Ashley Field for their support throughout this project.

Plant material was collected under the Christmas Island Plan of Management and spore germplasm imported to the mainland under the Department of Agriculture, Water and the Environment Biosecurity Import Conditions case "Permitted Seed for Sowing".

Funding was provided by the Parks Australia executive as part of the "Flora Prioritisation" project.

References

Butcher, R. and Hale, J. (2010). *Ecological Character Description for The Dales Ramsar Site*. The Australian Government Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available at: https://www.environment.gov.au/water/wetlands/publications/dales-ramsar-site-ecological-character-description

Di Fonzo, M.M., Nicol, S., Possingham, H.P., Flakus, S., West, J.G., Failing, L., Long, G. and Walshe, T. (2017). Cost-effective resource allocator: a decision support tool for threatened species management. *Parks* 23: 101-113.

Holmes, G. and Holmes, J. (2002). *Conservation Status of the Flora of Christmas Island, Indian Ocean*. Environment Australia/Parks Australia North, Atherton.

Threatened Species Scientific Committee (2004). *Commonwealth Listing Advice on* Pneumatopteris truncata *(fern)*. Australian Government Department of Agriculture, Water and the Environment. Available at: http://www.environment.gov.au/biodiversity/threatened/species/p-truncata.html

Dealing with Physical Dormancy in Tasmanian *Pomaderris* (Rhamnaceae) collections: Heat shock, seed size and mould issues

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The presence of physical dormancy (PY) in the seeds of Rhamnaceae is widely recognised by seed practitioners and has had some study (Hanley and Lamont 2000, Turner *et al.* 2005, Haines *et al.* 2010 Ooi *et al.* 2014). The need to develop an efficient technique to alleviate PY arose from a larger study into seed dormancy in Tasmanian populations of *Pomaderris* species. A dry heat shock treatment was selected for investigation, as hot water treatments were considered cumbersome when processing large quantities of small seed in a short amount of time. Initial investigations were conducted on a collection of *Pomaderris pilifera*. Heat shock (HS) treatments were applied with using a laboratory, fan assisted oven (Binder FD115) and two 6 cm deep, stainless steel steam pans filled with 1.5 cm depth of dry sand (Figure 1a). To apply HS the steam pans were placed in the oven and brought to temperature over two hours. Seed samples were placed in a mono layer within folded aluminium foil envelopes. The envelopes are then placed flat on the sand surface of one tray (Figure 1b) and the second tray is then placed on top to sandwich the envelopes between the two bodies of heated sand and returned to the oven (Figure 1c). Envelopes were retrieved after the allotted time (Figure 1d). A control treatment (i.e., seeds neither scarified nor heated) and a manual scarification trial were also conducted to gauge the effectiveness of the HS treatments. Germination trials consisted of 3 x 40 seeds from each treatment sown on 9 cm Petri dishes of 1% agar. Remaining seeds were cut test at the end of the test. Treatments and results are presented in Table 1.

The control test confirmed the presence of PY in the *Pomaderris* collection. Surprisingly the HS trials proved to be far more effective than the manual scarification trial, partly due to seed succumbing to mould. Short durations at 90°C proved to be ineffective at alleviating PY and on cut test most seeds were found to have not imbibed. Treatments at 105-120°C were found to effective at alleviating PY with little differences in final percentage result or germination rate (Table 1). The amount of fine mould on seeds and elaiosome did differ however with decreasing amounts of mould observed as treatments became hotter and longer. At 120°C for 10 minutes almost no mould growth was observed.

Table 1. Heat shock trial results for *P. pilifera*.

Treatments	mean %	s.e	t50 (d)
15°C (control)	0.8	0.8	14.0
Chip-> 15°C	30.8	5.5	22.5
HS (90°C/1m)-> 15°C	34.7	1.4	30.3
HS (90°C/2m)-> 15°C	41.5	2.3	25.7
HS (90°C/5m)-> 15°C	62.7	7.5	27.7
HS (90°C/10m)-> 15°C	78.2	5.4	29.4
HS (105°C/1m)-> 15°C	84.6	3.9	26.3
HS (105°C/2m)-> 15°C	89.2	4.4	25.7
HS (105°C/4m)-> 15°C	80.7	4.3	25.7
HS (105°C/10m)-> 15°C	88.3	4.1	25.7
HS (120°C/1m)-> 15°C	87.3	0.1	24.7
HS (120°C/4m)-> 15°C	89.2	5.8	24.1
HS (120°C/10m)-> 15°C	94.1	3.1	24.6

(mean % = mean of final germination result; s.e. = standard error of final germination results; t50 = mean time (in days) to achieve 50% of final germination result.)

Further testing was conducted with a collection of *Pomaderris elliptica* to assess the upper tolerance level for HS treatments. Heat shock temperatures of 100, 120, 140 and 160°C were applied for 5-, 10- and 15-minute intervals. The results (not shown) confirmed that 120°C for 10 minutes is within a safe optimal range for breaking physical dormancy with good results at 5, 10 and 15 minutes. 140°C for 5 minutes killed nearly all seeds and durations and temperatures above that were completely lethal. These findings are in line with other reports of HS treatments in Rhamnaceae (Hanley and Lamont 2000, Ooi *et al.* 2014). Hanley *et al.* (2003) and Williams *et al.* (2003), studying a range of Australian legumes, reported that smaller seeded species have higher temperature tolerances. The seed mass of *Pomaderris* sits right at the lower end of the seed weights for the legumes in those studies, so it looks as though the correlation extends beyond Legumes. Overbeck *et al.* (2006) observe the same seed size/heat correlation for Brazilian grassland herbs, but Gashaw and Michelson (2002) report the reverse correlation for Ethiopian savannah species with larger seeds surviving higher temperatures.

Figure 1. Sand pan heat shock application. Photos: J. Wood

Routine testing of *Pomaderris* collections within the Tasmania Seed Conservation Centre (TSCC) has identified a small number of collections (9 out of 55) succumbing to mould very rapidly and reducing total germination. As all 55 collections had been handled identically the reason for this is unclear but the pathology is most likely imbibition shock. Higher germination results by slowly imbibing the seeds over water (after PY alleviation but before sowing on agar) appears to confirm this. It was also found that higher levels of germination were scored if these collections were sown into pots of compost rather than onto plates of agar. This suggests that issues of imbibition shock are in part a product of the testing medium and therefore the phenomenon would not carry over to field sowing. It may be worth considering whether boiling water treatments can also result in imbibition shock, if poor results are achieved using that technique.

References

Gashaw, M. and Michelsen, A. (2002). Influence of heat shock on seed germination of plants from regularly burnt savanna woodlands and grasslands in Ethiopia. *Plant Ecology* 159: 83-93.

Haines, L., Ennis, I.L., Blanchon, D.J. and Triggs, C.M. (2007). Propagating the pale-flowered kumarahou (*Pomaderris hamiltonii*) and kumarahou (*Pomaderris kumeraho*) from seeds. *New Zealand Journal of Botany* 45(1): 91-100.

Hanley, M.E. and Lamont, B.B. (2000). Heat pre-treatment and the germination of soil- and canopy-stored seeds of south-western Australian species. *Acta Oecologica-International Journal of Ecology* 21: 315-321.

Hanley, M. E., Unna, J.E. and Darvill, B. (2003). Seed size and germination response: a relationship for fire-following plant species exposed to thermal shock. *Oecologia* 134: 18-22.

Ooi, M.K.J., Denham, A.J., Santana, V.M. and Auld, T.D. (2014). Temperature thresholds of physically dormant seeds and plant functional response to fire: variation among species and relative impact of climate change. *Ecology and Evolution* 4: 656-671.

Overbeck, G.E., Müller, S.C., Pillar, V.D. and Padenhauer, J. (2006) No heat-stimulated germination found in herbaceous species from burned subtropical grassland. *Plant Ecology* 184: 237–243.

Turner, S.R., Merritt, D.J., Basskin, C.C., Dixon, K.W. and Baskin, J.M. (2005) Physical dormancy in seeds of six genera of Australian Rhamnaceae. *Seed Science Research* 15: 51-58.

Williams, P.R., Congdon, R.A., Grice, A.C. and Clarke, P.J. (2003). Fire-related cues break seed dormancy of six legumes of tropical eucalypt savannas in north-eastern Australia. *Austral Ecology* 28: 507-514.

Investigating cryopreservation options for *Syzygium maire*, a threatened endemic New Zealand tree

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Introduction

Syzygium Gaertn. is the largest genus in the Myrtaceae family. New Zealand is home to one species, *S. maire* (Swamp maire, Maire tawake, Waiwaka). This 16 m tall glabrous tree is endemic and mostly found in waterlogged ground or on margins of streams in lower lying areas, although some populations occur in montane or cloud forests (de Lange *et al.* 2018) (Figure 1). *Syzygium maire* has fleshy red berries which develop over 8–11 months, maturing during early summer in populations at low altitudes (< 200 m.a.s.l.) or in autumn at higher altitudes (> 500 m.a.s.l.; Figure 2). In the higher altitude populations, mature fruits and flowers can be observed on the same plant simultaneously. Globally, *Syzygium* species are valued for medicinal properties (*S. aromaticum* – clove) or as a food source (*S. cumini, S. jambos, S. malaccense, S. samaragense);* similarly, *S. maire* berries have 18 times more antioxidants compared to blueberries (Gould *et al.* 2010). Limited information has been published on the ecology of *S. maire* but honey bees and birds, such as Tui (*Prosthemadera novaeseelandiae*), Stitchbird/Hihi (*Notiomystis cincta*) and Bellbird/Korimaki (*Anthornis melanura*) have been observed competing for access to nectar, while the New Zealand Pigeon/Kererū (*Hemiphaga novaeseelandiae*) favours mature berries (Figure 3). *Syzygium maire* is mostly found in the North Island although isolated populations occur in the north-east corner of South Island around Blenheim and Nelson. Clearing and draining of large tracts of forest and wetlands for settlements and pasture resulted in significant loss of habitat. Despite this, *S. maire* was only considered as threatened for the first time in 2018 when it was listed as Nationally Critical due to the predicted impact from Myrtle Rust (*Austropuccinia psidii*) (de Lange *et al.* 2018). This prediction is based on the impact of Myrtle Rust on fleshy fruited Myrtaceae species in Australia. Two species, *Rhodamnia rubescens* and *Rhodomyrtus psidioides*, have been decimated by Myrtle Rust, illustrating that pre-emptive *ex situ* conservation is easier and less expensive if done prior to impacts on reproductive capacity (Sommerville *et al.* 2019).

As *S. maire* seeds are metabolically active and shed at high moisture contents, the only long-term seed storage option is likely through cryopreservation of zygotic embryos (van der Walt *et al.* 2020a). Key to cryopreservation is the control of the dehydration process and limitation of injury from chemical toxicity during treatments involving concentrated cryoprotectant solutions such as Plant Vitrification Solution (PVS2) (Sakai 2004). In this study we aimed to (a) optimise embryo culture, (b) investigate the impact of desiccation on embryo viability, and (c) examine the effect PVS2 exposure on embryo survival and plantlet development.

Figure 1. Swamps dominated by *Syzygium maire* at Fensham Reserve. Photo: K. van der Walt

Figure 2: Mature *Syzygium maire* berries in habitat. Photo: K. van der Walt

Figure 3. New Zealand Pigeon/Kererū chick swallowing a mature *Syzygium maire* berry. Photo: David Mudge, Nga Manu Trust

Materials and Methods

Syzygium maire fruits were collected over three consecutive summers (2018–2020) from Fensham Reserve and Midhirst (Figure 4). Fruits were mixed with two parts medium grade vermiculite (Ausperl Australia) and stored in airtight containers at 5°C until use. Prior to embryo excision, fruits were surface sterilized by submersion in 50% Janola® (4% sodium hypochlorite) for five minutes. The pulp and seed coat were removed aseptically to expose the radicle tip enabling the excision of the embryonic axes (hereafter referred to as embryos). Once embryos were removed from the cotyledons, these were submerged in 5g/L sodium dichloroisocyanurate (NaDCC). Each sterilisation step was followed by three rinses in sterile distilled water. Sterilised embryos were cultured on solid Murashige and Skoog (MS) medium supplemented with 3% w/v sucrose and incubated at 15/25°C with a 16 h dark/8 h light cycle.

To determine the effect of desiccation on embryo survival, excised embryos were desiccated in a laminar air flow cabinet for 0, 1, 2, 3, 4, 5 and 6 hours. For each desiccation treatment embryo viability was determined through germination as described above, while moisture content was calculated after drying at 103°C for 17 h and expressed on wet weight basis.

Solutions used for vitrification protocol included loading solution (LS), PVS2 and washing solution (WS). LS consisted of MS with 2.0 M glycerol and 0.4 M sucrose. PVS2 consisted of MS with 0.4 M sucrose, 30% w/v glycerol, 15% w/v ethylene glycol and 15% w/v dimethyl sulfoxide (DMSO). WS consisted of MS with 0.75 M sucrose. Sterilised embryos were placed in LS for 20 min then transferred to PVS2 for various incubation times (30, 60 or 90 min). The LS and PVS2 steps were conducted at room temperature and 0°C. After PVS2 incubation embryos were soaked in WS for 20 min and transferred to culture medium for viability assessment. All experiments were conducted using 10 embryos and replicated four times.

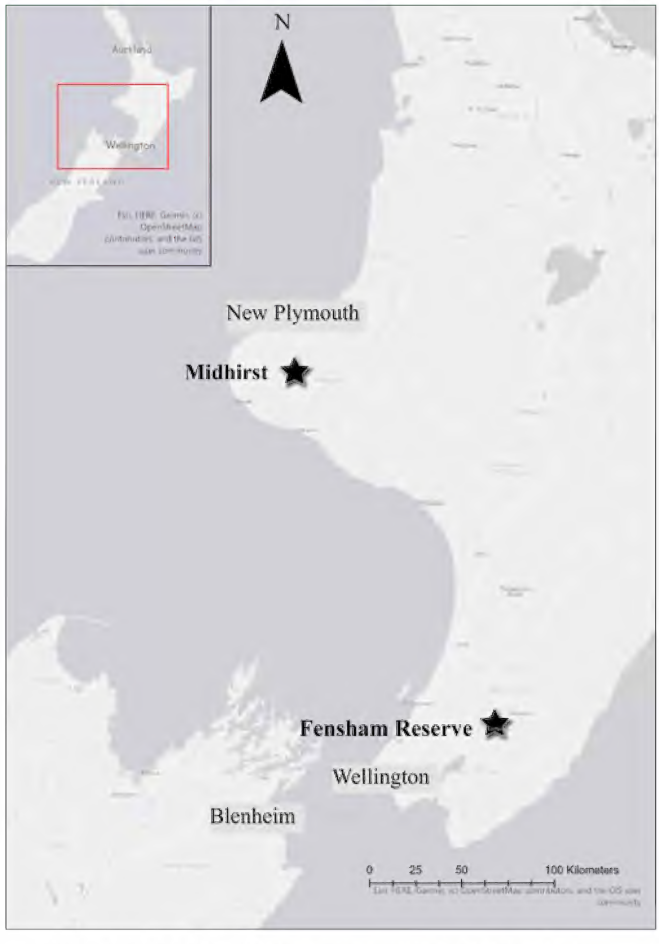

Figure 4. Locality of Fensham Reserve and Midhirst where *Syzygium maire* fruits were collected. Image: K. van der Walt

Results

Untreated embryos (controls) had high moisture content (64.38 ± 0.5%) and 100% viability. Radicle growth was observed after seven days and the first set of leaves were fully developed within 20 days (van der Walt *et al.* 2020b). Desiccating embryos for up to 2 h had no significant impact on viability or moisture content. However, embryos desiccated for 3 h had a significant reduction in moisture content (25.4 ± 1.3%) and although viability loss was recorded (86.6 ± 15.3%), it was not significant. Low survival was associated with further desiccation (Figure 5).

Exposure to PVS2 had a significant effect on embryo survival with lowest survival (63.3%) associated with 90 min exposure to PVS2. Survival rate was not affected by temperature (0°C or 20°C). Plantlet development was also negatively affected by PVS2 exposure, with some embryos showing radicle, but not shoot, development following exposure to PVS2 for 60 min or longer (Figure 6).

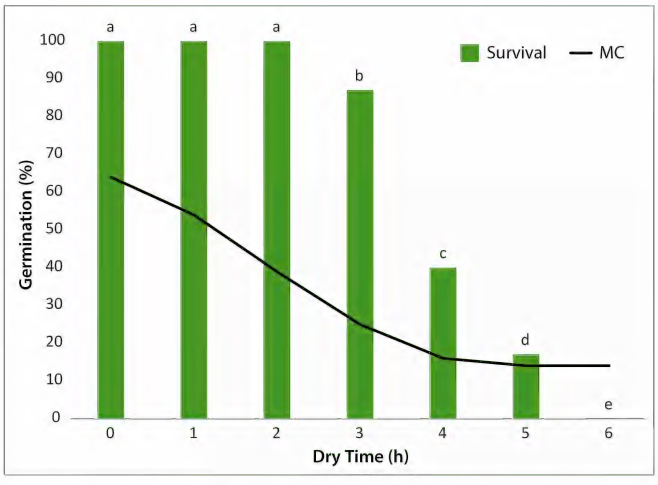

Figure 5. Germination (%) of *Syzygium maire* embryos desiccated for 0–6 h. Values followed by the same letter do not differ significantly (Fisher's, P < 0.05; N = 10; MC = Moisture Content).

Conclusion

These results demonstrate that *S. maire* embryos are metabolically active, shed at high moisture contents and although initial viability is high, desiccation is detrimental to survival. Exposure to PVS2 for longer than 30 min negatively impacted embryo viability and plantlet development therefore additional steps to optimise embryo survival could include the use of the novel droplet vitrification method which will limit exposure to PVS2 (van der Walt *et al.* 2020b).

Acknowledgements

We acknowledge and thank the New Zealand Department of Conservation (DOC) for the permission to collect fruit from the Taranaki region under DOC Permit number 69441-FLO. Special mention must be extended to the Te Rūnanga o Ngāti Ruanui, Te Kotahitanga o Te Atiawa and Te Korowai o Nga Ruahine Iwi Authorities for allowing access to their takiwā from which the

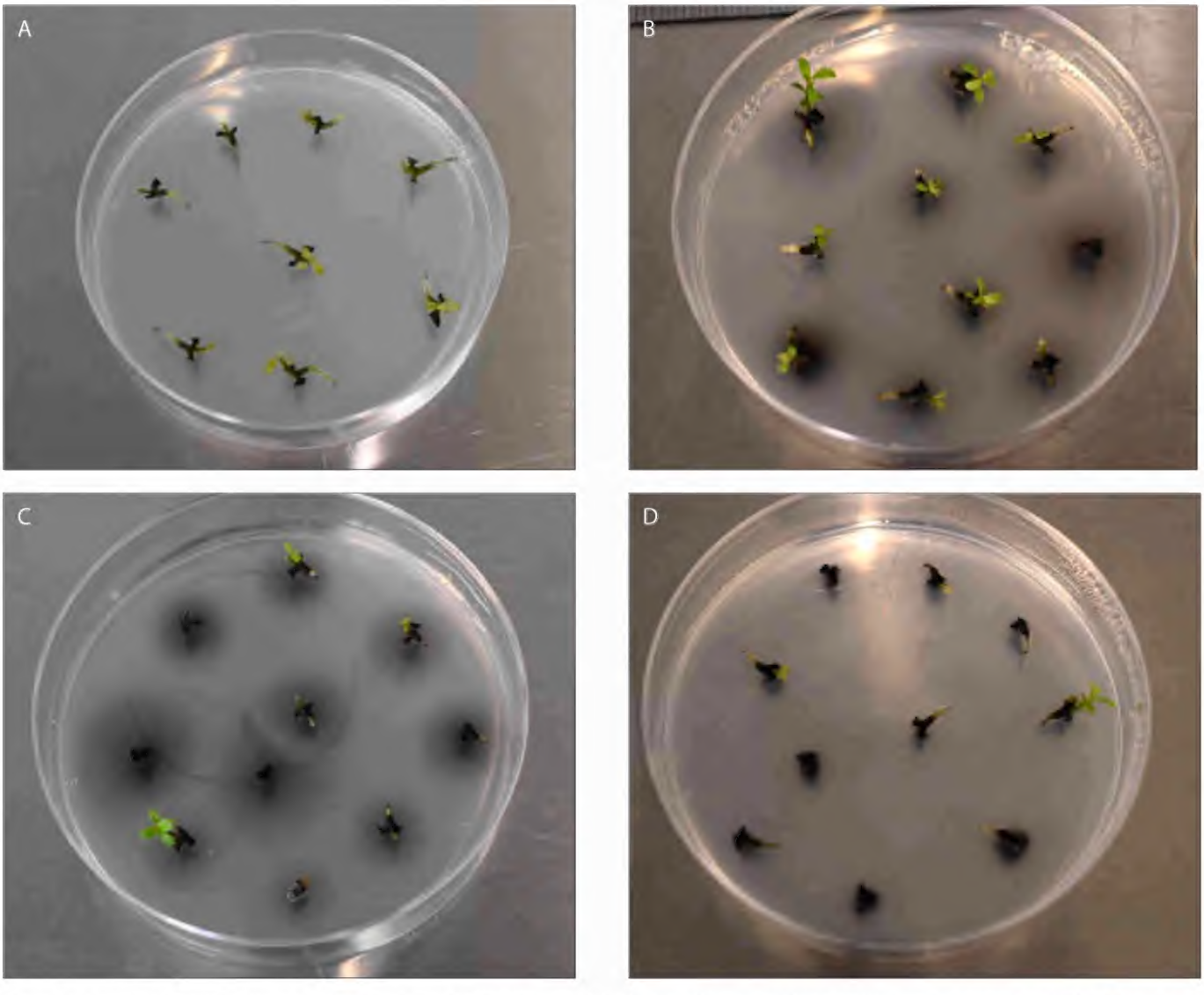

Figure 6. *Syzygium maire* embryo survival and plantlet development 10 weeks after exposure to PVS2 at room temperature for (a) 0 min, (b) 30 min, (c) 60 min and (d) 90 min.

seed was collected. Funding for this project by the Ministry for Primary Industries (MPI), New Zealand (Project 18608) is greatly appreciated. Bill Clarkson (private) and James Jones (Otari) are thanked for fieldwork assistance while Cliff John provided access to land. The work was undertaken at the Otari Garden with the findings of this work being communicated with representatives of Port Nicholson Trust of Wellington.

References

de Lange, P.J., Rolfe, J.R., Barkla, J.W., Courtney, S.P., Champion, P.D., Beadel, S.M., Ford, K.A., Breitwieser, I., Schonberger, I., Hindmarsh-Walls, R., *et al.* (2018). *Conservation status of New Zealand indigenous vascular plants, 2017*. In: New Zealand Threat Classification Series 22. Department of Conservation, Wellington.

Gould, K.S., Thodey, K., Philpott, M. and Ferguson, L. (2010). Antioxidant activities of extracts from traditional Maori food plants. *New Zealand Journal of Botany* 44(1): 1-4.

Sakai, A. and Engelmann, F. (2008). Vitrification, encapsulation-vitrification and droplet vitrification: A review. *CryoLetters* 28(3): 151-172.

Sommerville, K.D., Cuneo, P., Errington, G., Makinson, R.O., Pederson, S., Phillips, G., Rollason, A., Viler, V. and Offord, C.A. (2020). Conservation in the wake of myrtle rust – a case study on two critically endangered Australian rainforest plants. *Pacific Conservation Biology* 26: 218-229.

Van der Walt, K., Kemp, P., Sofkova-Bobcheva, S., Burritt, D.J. and Nadarajan, J. (2020a). Seed development, germination, and storage behaviour of *Syzygium maire* (Myrtaceae), a threatened endemic New Zealand tree. *New Zealand Journal of Botany*: https://doi.org/10.1080/0028825X.2020.1794911.

Van der Walt, K., Kemp, P., Burritt, D., Sofkova-Bobcheva, S. and Nadarajan, J. (2020b). Evaluation of droplet vitrification, vacuum infiltration vitrification and encapsulation-dehydration cryopreservation for *Syzygium maire* zygotic embryos. *CryoLetters*. In press.

News from the Australian Seed Bank Partnership

Ten years of an Australian *ex situ* seed conservation partnership

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The Global Strategy for Plant Conservation (GSPC) provides the plant conservation community with a clear set of targets, goals and objectives under which conservation actions can be identified and delivered. The commencement of the second decade of the GSPC coincided with another formal collaboration for which Australia continues to enjoy local, national and international support-the establishment of the Australian Seed Bank Partnership.

For many years prior to 2010, the major *ex situ* conservation seed banks across Australia collaborated through the Australian Conservation and Research Network (AusCAR), providing opportunities to share information and collaborate on critical research into the Australian native flora. Following almost a decade of funding and capacity building through the Millennium Seed Bank Project of the Royal Botanic Gardens, Kew, UK, the seed banks and conservation organisations of AusCAR transitioned to a new partnership arrangement. In 2010, The Council of Heads of Australian Botanic Gardens with substantial assistance from Dr Lucy A. Sutherland, established the Australian Seed Bank Partnership (the Partnership), a formal collaborative network of conservation seed banks and flora-focussed organisations operating across Australia.

The Partnership's national program has largely been guided by the GSPC, with specific Australia-based priorities and actions identified through the Partnership's Business Plan. This ambitious, ten-year Business Plan outlined strategies, actions, priorities and key outcomes intended to guide seed collections, storage, research and restoration work. The Business Plan provided a focus for ensuring the Partnership's work remains relevant to our vision of a future where Australia's native plant diversity is valued, understood and conserved for the benefit of all.

While the $12 million Business Plan remained largely unfunded throughout its implementation, substantial investments were made by Partner institutions, governments and philanthropic granting organisations and individuals to support our work. Millions of dollars of investment from Partner institutions have been directed towards staff and facilities with major upgrades to equipment and critical infrastructure.

Beyond cash investments, the backbone of the Partnership continues to be the people. Many seed bank staff, students and volunteers have contributed their expertise, enthusiasm and dedication to ensuring Australia's native flora are provided the best possible opportunities for survival, both *ex situ* and *in situ*.

Many thousands of Australia's native taxa are continuing to benefit from long-term seed conservation, targeted research and numerous restoration and translocation trials as a result of the dedication and investment of so many individuals and organisations. Collectively these have informed better on ground outcomes from the utilisation of *ex situ* seed collections.

At the end of this decade we thought it would be good to look back at some of the contributions and achievements that the Partnership worked hard to support.

1000 Species Project

The 1000 Species Project provided an overarching framework for securing collections of endangered, endemic and economically important species in two phases under Partnership-funded projects. The first phase aimed to secure species not previously represented in seed banks, with the second phase focussed on increasing the genetic diversity of those same collections. The target of 1000 species was surpassed in 2019, with over 1,300 new taxa secured in seed banks across the network. Improving the genetic diversity of these collections is continuing as funders are increasingly recognising the importance of genetic diversity in *ex situ* collections and, new projects in 2020 and beyond are enabling the partners to prioritise these efforts.

Global Trees Seed Bank Project

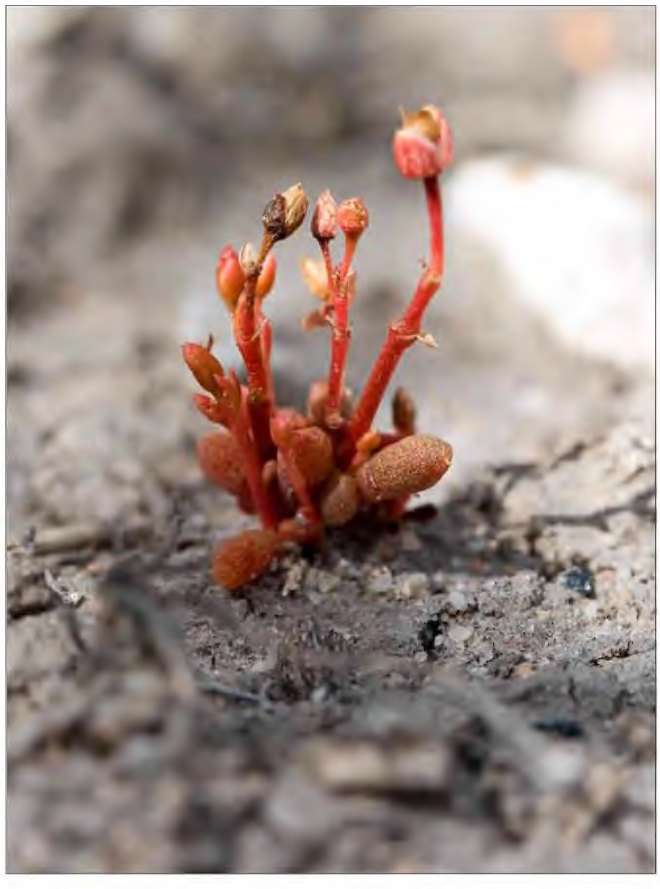
What started out as a four-year project became more than five years of collecting across the country securing seeds from endemic Australian trees such as the critically endangered *Wikstroemia australis* and the endangered *Phebalium distans*. Commencing in 2014, the Global Trees Campaign and the Millennium Seed Bank Partnership, with funding from the Garfield Weston Foundation, worked with existing and new Partners around the world to build *ex situ* seed collections of threatened tree species.

Ben Wirf and Bobby Maralngurra collecting in Kakadu National Park. Photo: Tom North, ANBG

The Australian Seed Bank Partnership's goal was to contribute 380 tree species towards the project's global collection target of 3,000 tree species. By the end of the five years, the Partnership had secured 503 taxa that are stored securely in *ex situ* conservation seed banks around Australia, with the majority of these duplicated at the Millennium Seed Bank.

Fieldwork Funds

Another important collecting initiative was the Fieldwork Funds project, supported by the Millennium Seed Bank Partnership and the Grantham Foundation. This very successful collecting project aimed to secure seed from species not previously represented in seed banks with a focus on threatened species, including undescribed species and those that were known to be conservation dependent or that were part of threatened ecosystems. Collections were made in all states and territories with 773 taxa secured, including the critically endangered *Prasophyllum milfordense* in 2013/14; *Androcalva bivillosa* in 2014/15; *and Genoplesium insigne* in 2016/17.



***Calandrinia operta* – from massive trees to minute herbs our collectors have scoured the landscape for native species of any size and form. Photo: Andrew Crawford, DBCA**

Crop Wild Relatives

In 2017–2019 we were pleased to have the opportunity to partner with the Australian Grains Genebank to deliver two field trips to the Northern Territory to collect crop wild relatives and improve local and regional capacity for seed conservation. Funding from The Crop Trust and the Millennium Seed Bank Partnership supported trainees and collectors as well as providing field collection kits to Kakadu's Indigenous Rangers that will enable them to undertake seed collecting in the years ahead. The project secured 43 collections of 22 taxa and provided training to Traditional Owners from Jabiru, Indigenous school-based trainees, Kakadu National Park Women's Rangers, and Djurrubu Rangers as well as seed scientists from Papua New Guinea and Indonesia. Access and Benefit Sharing agreements will be developed with Traditional Owners on a species by species basis should future research be identified for the collected species for pre-breeding trials. Such research is likely to explore the development of modern crop cultivars that may have beneficial traits such as drought tolerance and disease resistance.

Leionema equestre **is an endangered Kangaroo Island endemic that has been impacted by both pathogens and bushfires. Photo: Dan Duval, BGSH**

Preparing for the impacts of disease

Many introduced pathogens pose significant risk to the Australian native flora, and the Partnership has worked hard to contribute to national and international efforts to combat their impacts. Two projects in 2012/13 and 2016/17 were funded by the Australian Government and formed part of the recommended actions identified in the 'Threat Abatement Plan for disease in natural ecosystems caused by *Phytophthora cinnamomi*'. Collectively these projects enabled the Partners to secure 102 collections from 51 taxa over two years from species most at risk of dieback caused by *P. cinnamomi*. These included collections of the endangered *Leionema equestre* from two roadside populations in the east and a single disjunct population from the north of Kangaroo Island. The project also secured the critically endangered *Prostanthera marifolia* whose wild plants produced limited seed, but cuttings grown on at Mt Annan Botanic Gardens nursery matured successfully with seed harvested for *ex situ* conservation. This was identified by Partners as one of our most effective projects for securing genetically diverse collections.

In early 2017, *Austropuccinia psidii* was discovered on the north island of New Zealand, and ever since our Partners have shared information and delivered in-country training in seed collections and myrtle rust identification. Our continued participation and knowledge sharing through the Myrtle Rust Environmental Impacts Working Group benefits our understanding of the continued threat to native species throughout Australia. The ANPC's current *Fire and rust – the impact of myrtle rust on fire regeneration* project through the NESP Threatened Species Recovery Hub will help inform future post-fire germplasm capture to ensure myrtle rust-affected species are prioritised.

Phytophthora cinnamomi **has devastated many areas throughout southern Australia. Photo: Brett Summerell, RBGDT**

Contributing to the development of national standards

The extensive expertise within the Partnership has enabled us to contribute to the development of guidelines and standards in collaboration with other experts and organisations around the country. We were pleased to support the Society for Ecological Restoration Australasia to prepare the world's first set of standards to guide best-practice restoration in Australasia. The standards were developed over a three-year period presenting the principles underpinning restoration philosophies and methods, and outlining the steps required to plan, implement, monitor and evaluate a restoration project to improve its chances of success. These were subsequently launched at the National Seed Science Forum in 2016.

In 2017 the Partnership contributed to an international seed science workshop at Kings Park in Western Australia which informed the development of the first-ever global standards to describe, measure, analyse and record information about seed traits. Much work continues in this area with many in the Partnership continuing to be closely involved.

Over the past several months and well into the coming year, the experts across the Partnership are contributing to the review and development of updated Germplasm Guidelines and Florabank Guidelines. The ANPC, in particular Amelia Yenson and Lucy Commander are doing a brilliant job of coordinating numerous contributors, with many authors contributing to both publications, including the many case studies in this edition of APC. We look forward to the launch of both sets of guidelines in the coming year.

Australian Seed Bank online

Through many years of collecting and research activities, our partner organisations have documented significant data on the phenology of specific plants as well as on their ecology, abundance, seed morphology and germination, dormancy and storage requirements. At the start of the decade the Partnership, with support from the Atlas of Living Australia (ALA) developed the *Australian Seed Bank online*, an open access portal of seed collections held across the Partnership. The portal is showing its age and the Partners have identified improvements to its functionality that would inform national collecting priorities and guide future investment in seed conservation. We are working with the ALA to enable these updates to occur and ensure this resource continues to be available for the sector. https://www.seedpartnership.org.au/initiatives/AustralianSeedBankOnline

National Seed Science Forum and the Australasian Seed Science Conference

An important focus for the Partnership is sharing knowledge and engaging with a wide range of individuals and organisations. In March 2016 we brought 145 researchers and conservation and restoration practitioners from more than nine countries together to participate in the very successful National Seed Science Forum. In 2020 we rebranded to the Australasian Seed Science Conference to recognise the significant regional interest. Our postponed 2020 conference will now take place in September 2021 with more information on the program to be released early in 2021. To stay up to date with preparations for the conference we invite you to sign up to our conference mailing list at https://www.seedscience2021.com.au

Australian Bushfires and the next ten years

In 2017 the Australian PlantBank was recognised by Botanic Gardens Conservation International's Global Seed Conservation Challenge for its significant contribution to *ex situ* seed conservation internationally. In addition, during the Millennium Seed Bank's 20th anniversary celebrations, Australia's conservation seed banks were recognised for making the largest contribution of collections with more than 12,300 collections duplicated in the UK.

These achievements demonstrate that the work of our conservation seed banks is of national and international importance, contributing in many ways to broader efforts to conserve our rich plant diversity.

The Australian Bushfires of 2019/2020 served to galvanise support for plant conservation with seed banks recognised for the role they play, resulting in the Partnership securing more than $1.7 million for collecting, germination and the utilisation of collections over the next three years. This investment in the sector comes at the same time as many other projects and collaborations our Partners are delivering on across the country. The next three years are going to be busy for many of us as and with large investments in the sector, such as through Greening Australia's Project Phoenix, the next ten years are likely to see significant changes to seed-based conservation activities. The Australian Seed Bank Partnership looks forward to working with all of its Partners, Associates and supporters over the next decade to continue to safeguard Australia's flora for future generations.

ANPC Workshop and Publications report

Riverina LLS Hay Plains Workshop

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A fantastic autumn seasonal break and extended winter rains have provided the ideal opportunity for the first live field ANPC supported workshop of 2020. The workshop was organised by Sally Ware of Riverina Local Lands Services (LLS) and occurred under COVID-19 safe principles with participation limited to 20 individuals.

The intent of the day was to focus on plant identification in the field and also look at specimens that were brought along to the meeting point at the Booligal Hotel. A wide range of resources including the now out of print Native Vegetation Guide to the Riverina and Plants of Western NSW were available for use. There was discussion on the need for the republication and provision of digital access for some of these key resources for plant identification and landscape profiles.

The field component of the day was focused on the chenopod shrublands and grasslands at sites on Waljeers and Bedarbigal stations and some of the interspersed sandhills and prior stream soils. The issues of encouraging natural regeneration, direct seeding and planting of a wide range of tree and shrub species on these soils was discussed. With the forecast La Niña conditions it is due to be a bumper year for seed collection so there was also talk on how to collect seed from a range of species.

It was a great day out on the plains with most of the country looking the best it's been for many years. A pleasant socially distanced lunch was held alongside Lake Waljeers, which was full and a haven for the many species of water birds that have migrated in with the recent high river flows.

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Boree/ Weeping Myall (*Acacia pendula*) and open Riverine Grasslands site inspected on Bedarbigal Station, Hay NSW. Photo M. Driver

Special feature

An overview of the ANPC Audit of Seed Production Areas in NSW Report

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Background

In the Spring issue of APC we highlighted the Australian Native Seed Survey report (Hancock *et al*. 2020). This survey found future seed demand will be difficult to meet from wild harvest and recommended an investigation of Seed Production Areas (SPAs). Well known in the restoration sector, SPAs are plant populations established to produce seed of known genetic and geographic origin which can be used to increase seed quality and availability for restoration, functional and amenity landscaping, bush food and fodder markets. These SPAs are pivotal in supplying native seed for ecological restoration. However, it was unknown if SPAs could produce genetically appropriate seed, the costs of production, and if SPAs could function self-sustainably after funding ceased. To answer these questions, an audit of SPAs was undertaken as part of the Healthy Seeds project funded by the NSW Environmental Trust. The audit examined the availability of existing seed infrastructure and regional resources in NSW, and investigated the barriers and opportunities in the seed and restoration sectors.

Audit Method

Participants from Local Land Services, Landcare, seed suppliers and other interested parties in NSW were invited to contribute to the state-wide survey, which was conducted between December 2019 and March 2020. A total of 30 native seed entities contributed to the audit process though an email survey and phone interview. Survey questions were developed by Martin Driver and can be found in Appendix 1 of the SPA Audit report, available from the ANPC website: https://www.anpc.asn.au/wp-content/uploads/2020/12/Final-Edited-Audit-SPA-NSW-Report-_Consortium- Adopted.pdf.

Key findings

An investigation into known projects funded over the past 20 years managed to locate few actively managed SPAs in NSW. The Murray LLS seed bank and SPA network is the only identified regionally and vertically integrated seed supply system that is capable of servicing seed and works across a significant area. The network was established primarily to supply seed for direct seeding restoration projects across the Murray catchment as well as to provide seed to a range of community and commercial nurseries. The network currently consists of 14 SPA sites, producing seed from 25 species and a centralised processing, seed bank and storage facility. The network is backed by an integrated database and seed tracking system.

Replanting Seed production area at Berrigan NSW. Photo: Susan Logie

One identified Landcare Group in the central west of NSW established four SPAs, but over time, the drought, a lack of funding to maintain sites and limited hours to manage the sites resulted in them becoming unproductive. The group currently uses volunteer labour to collect extremely limited seed from depleted wild populations for nursery production for local projects. This highlights the need to invest in coordination, training and maintenance of SPAs and the continuity of funding to regional projects to justify SPA establishment and management.

The following key findings were identified by the audit:

- SPAs are not regularly providing seed for restoration works[1].

1 Except for Canberra Greening Australia, Greater Sydney, a Landcare Group in the central west and Murray Local Land Services

- Due to the lack of continuity of staff, projects and maintained records, it was difficult to identify SPAs in NSW.
- Apart from Murray LLS and Greening Australia, SPAs are not providing species suitable for regional restoration. Instead, seed for restoration is being sourced from commercial suppliers, local Landcare volunteer networks and seed banks where available.
- There were few examples of SPAs being rehabilitated, so it was difficult to establish if it is more cost effective to create a new SPA or rehabilitate an existing one. Good records would be needed to determine if old SPAs could produce genetically appropriate seed.
- Some restoration projects could be designed as SPAs to deliver better value for money. However, additional funds would be needed to plan, design, establish and provide ongoing maintenance for these sites.
- **Tracking systems.** Across both government and non-government organisations there are limited computer-based tracking systems operating. Non-government organisations have limited resources to invest in tracking systems.

LLS Murray SPA 'Ulunja' established in 2016 with funds from NSW Environment Trust. Photo: Susan Logie

- **Licencing.** The survey found that 61% of non-government organisations and 50% of government agencies did not have a current licence to collect native seed in NSW. Allowing time to apply for a licence, the process being perceived as unduly arduous and the complexity of reporting and compliance systems, contributed to the difficulties of licencing.
- **Succession planning and training.** Many seed collectors are in their fifties and sixties so there is concern about succession planning over the next decade as the workforce ages.

Barriers and opportunities

The barriers reported varied across government or non-government organisations. Government organisations reported funding and seed demand variability as the largest barrier. Non-government organisations saw seed decline impacted by land access or climate as the largest barriers followed by licence permits and a lack of knowledge from clients about their seed requirements.

Opportunities identified by respondents included:

- Regional technical support, training and research.
- Regional coordination in project development, funding and delivery.
- The development of a tracking code of practice and improvements to licencing.

Use of learnings

The SPA Audit was one of the initial outcomes of the Healthy Seeds project and will lead to recommendations and implementation processes in the final Healthy Seeds Roadmap. This Roadmap, in conjunction with work from Greening Australia's Project Phoenix will provide a range of ideas and opportunities for co-ordination, resourcing and infrastructure to allow the native seed sector and key market drivers to function more effectively. National learnings on SPAs, including the results of this audit, are being incorporated into the Florabank Guidelines update (https://www.anpc.asn.au/florabank/), being conducted through the Healthy Seeds project. The new edition of the Florabank Guidelines will have a module on SPAs, and is due to be launched in early 2021. Those interested in the Guidelines are encouraged to contact the Florabank Project Manager, Dr Lucy Commander (https://www.anpc.asn.au/staff/).

The findings and recommendations of the Healthy Seeds project will be incorporated into Greening Australia's Project Phoenix: Native seed for bushfire recovery. As part of the national response to the 2019–20 bush fires, this 16-month program aims to develop a 10-year national native seed strategy.

ANPC member profile

Stanthorpe Rare Wildflower Consortium

Background

The Granite Belt region of southern Queensland has a high degree of habitat diversity due to its elevation, topographic variation, outcropping rock and a pronounced east-west rainfall gradient. Vegetation includes tall open forest and woodland on rocky slopes, grassy open forests and woodlands on the deeper soils of lower slopes and alluvial plains and shrub lands on rock pavements. 45% remains as remnant vegetation and 12% (17,000 ha) is contained within conservation reserves including Girraween and Sundown National Parks. Over 900 species of flowering plants occur in the region with 20 listed as threatened, including five recently classified as Critically Endangered on Queensland's *Nature Conservation Act*.

Beginnings and aims

In 2004, a group of local plant enthusiasts, landholders, Landcare organisations and representatives of a number of government agencies formed the Stanthorpe Rare Wildflower Consortium to promote the diversity of plants on the Granite Belt and work for the better protection and management of threatened species and vegetation communities.

The Consortium aims to extend knowledge through survey and monitoring work, workshops and publications and via the internet and social media. We collaborate with other conservation and natural resource management organisations, government agencies, educational institutions, landholders and other appropriate bodies in their efforts to better manage local ecosystems.

The Consortium assists local people and landholders with information and advice about flora and appropriate land management. The Southern Downs Regional Council and other government agencies call on our expertise for advice on the location of threatened species and we work with them in efforts to enhance conservation efforts.

Current work

We are currently undertaking a survey of two of our local Endangered boronias, *Boronia granitica* and *Boronia repanda*, to better determine their distribution and population numbers.

This year, we published the latest in a series of books on our local flora, Wattles of the Granite Belt, joining the third edition of one on eucalypts of the region and a comprehensive Flora of the Granite Belt, published in 2018. A book on local orchids is now in the early stages of preparation.

***Boronia granitica* (Granite boronia) in Passchendaele State Forest (southern Amiens section). Photo: Paula Boatfield**

After improved weather conditions this year, we were able to again conduct three of our very popular spring wildflower walks which were very well attended by local people and visitors from outside the region. These walks also provide an excellent opportunity to engage with local landholders. To help in the understanding of our local flora, particularly on these walks, in 2007 we published a booklet of over 280 photos of the most commonly seen wildflowers on the Granite Belt and are now into our third edition of this publication, having sold more than 8,000 copies to date.

Thoughts on the role of the ANPC

The ANPC network is a great way to link like-minded people and organisations from across Australia and provide an avenue for information exchange and inspiration. Priority needs to be given to advocacy to strengthen our state and national conservation legislation so that threatened plants and vegetation communities are properly protected and managed.

Contact: rwc@granitenet.com.au
Website: www.granitebeltwildflowers.com

Editor's note: ANPC welcomes Stanthorpe Rare Wildflower Consortium as a new community group member!

Book review

Black Mountain – a natural history of a Canberra icon

by Ian Fraser and Rosemary Purdie
Paperback, 160 pages, 17cm x 24.4cm. Published 2020. ISBN 978-0-6485419-1-2. RRP $35 (GST included).
https://www.friendsofblackmountain.org.au/AnniversaryBook

The newly published '*Black Mountain – a natural history of a Canberra icon*' will appeal to the amateur and professional naturalist alike. For the former, it provides an excellent introduction to the rocks, plants and animals of Black Mountain, and for the latter some guidance on more complex issues such as fire management and ecological surveys, with recommended areas for future research.

Black Mountain must be one of the most well studied reserves in Australia. With neighbours like the Australian National University, the Australian National Botanic Gardens, and the CSIRO (including the National Herbarium), as well as a large and keen local citizen science community, the plants have been well picked over by botanists who can just 'jump the fence' (although the same can't be said for non-vascular 'plants' and fauna). The first plant specimen was collected in 1927 and since then 728 vascular species have been recorded.

Being a keen bushwalker and living in Canberra, I have spent much time walking on Black Mountain. Although the bush looks similar, the number of recorded plant species here is significantly higher than other nearby reserves like Mt Ainslie and Mt Majura, and the orchid diversity is greater than anywhere else in the ACT. For example, of the 31 rare plants found on Black Mountain, 20 are orchids, and seven are nationally significant. I have often wondered why this was. The book surmises that the higher diversity on Black Mountain probably reflects the higher rates of collection. However, Chapter 2 on the geological history reveals that Black Mountain is an island of older sandstone surrounded by younger volcanic rocks, resulting is different soils and landforms. This makes we wonder if the higher diversity could also be due to the lower fertility of the sandstone, as in the Sydney basin where the Hawkesbury Sandstone vegetation has much higher diversity than the surrounding shale vegetation communities.

Chapter 3 provides a good regional context of the vegetation communities on the mountain at the national, regional and local levels, along with descriptions of the four Open Forest and one woodland and grassland structures - "All the native plants of Black Mountain are growing in a dry eucalypt forest habitat typical of the ranges associated with the south-western slopes inland of the Great Dividing Ranges".

Chapter 4 provides a terrific summary of the variety of plants on Black Mountain, changes recorded over time, characteristic understorey species, rare plants and introduced plants. I was particularly intrigued by the story of the 'missing' plants – those previously collected but not found again for decades. Five, including Fairies' Aprons (*Utricularia dichotoma*) were rediscovered by retired botanist and long-time ANPC member (and co-author of this book), Rosemary Purdie during intensive targeted searches between 2013 and 2017. All are small herbs associated with wet areas which are dormant as underground tubers or seeds during dry conditions, occurring only after prolonged rainfall. They were just hiding all that time. This highlights just how much we don't know, even in areas as extensively studied as Black Mountain. Imagine what species are waiting to be found in more remote, less studied areas, if only the resources were available!

Chapter 5 covers the diversity of vertebrate and invertebrate fauna that have been recorded on Black Mountain, the characteristic species, habitat preferences, bird migrations and the 'lost' animals such as the Brown Treecreeper, Hooded Robin and Painted Buttonquail due to the loss of suitable habitat. Feral animals are listed but their current control and management is surprisingly not covered.

Chapter 6 summarises the people who have searched and researched in the reserve, and provides an interesting summary of the top 10 plant collectors, including Rosemary whose collections represent nearly 14% of all plant specimens collected in the area, which is an astounding achievement.

Sprinkled throughout the book are little gems like the story of the backtracking scribbling moth larvae of the Scribbly Gums (*Eucalyputs rossi*) and the off-chance discovery that multiple moth species are involved. Like the excellent summary of the native plants used by the Ngunnawal people - I didn't know they ate bluebell (*Wahlenbergia* sp) flowers and used *Indigofera australis* to make fish poison! And detailed information on the mimicry of orchids – I learnt that to encourage insect

pollination, the local yellow donkey orchids mimic yellow pea flowers, and the helmet orchids resemble fungi.

Chapter 7 provides an excellent summary of five recommended bushwalks along with descriptions of some of the significant plant species you can see along the way.

Chapter 8 is an excellently detailed history of fire management in the reserve with timely descriptions of 'seeders' versus 'sprouters'. It emphasises the complexities of managing the ecological and social needs of any fire prone bushland reserve in an urban setting, and which relies on "meticulously planned and executed long term studies, detailed community consultation, and a willingness to adopt management practices which are firmly rooted in science." For example, one recent study (Mulvaney and Seddon, 2020) working with 32 volunteers found that "four of Black Mountain's rare orchid species are associated with frequently burnt areas, while another two occur only in long unburnt areas", complicating matters indeed.

Overall, this book is essential reading for anyone interested in Canberra's natural history, and especially in this Canberra icon. If only all our reserves had such detailed resource material available.

Reference

Mulvaney, M. and Seddon, J. (2020). Orchid diversity and occurrence in relation to past fire in Canberra Nature Park. *Australasian Plant Conservation* 28(3):20-22.

Jo Lynch

Publication notice

ILLUMINATING INDIGENOUS CULTURE THROUGH PLANTS

Researcher Zena Cumpston's new booklet on indigenous plants encourages their use and appreciation – providing a portal through which a wide audience may begin to understand the complexity of Indigenous scientific practice

I am a Barkandji woman, my mob are from western New South Wales but I have been living and working in Melbourne for many years. I am currently working part-time as a Research Fellow at the Clean Air Urban Landscapes (CAUL) Hub at the University of Melbourne.

Zena Cumpston says it's important that Indigenous Australians are the world's first scientists. Photo: Sarah Fisher, University of Melbourne

The CAUL Hub is funded by the Australian Government's National Environmental Science Program, and while there are many varied research imperatives within the work of the hub, we undertake research which aims to make urban areas healthier places for all living things.

Over the last two years my work has been focussed on Indigenous perspectives of biodiversity in urban areas. I have a deep love of gardening and plants, and it is through this passion that I found my interest in researching plant-use practices and plant knowledge of Aboriginal peoples across Australia, most especially the south-east.

I am unsettled by the lack of visibility of Aboriginal people and culture in urban areas and so I have focused on projects which allow illumination of our culture within this context.

If we look around in urban areas there is very little which attests Aboriginal custodianship, our deep histories and belonging. I believe that keeping our knowledges, practices, stories and histories marginalised no longer reflects the sentiment of the wider Australian society. As I am learning and researching more about our plant knowledges I am coming to better understand the landscape of knowledge production, especially related to limited and limiting perceptions of Aboriginal scientific practice and innovation.

Over countless millennia Aboriginal and Torres Strait Islander people have observed, interacted with and experimented with plants to harness their vast potential for nutrition, medicine and technologies. Our capacity to scientifically understand plants and develop often complex processes to support their cultivation and use has been pivotal in our ability to survive and thrive as the oldest living culture in the world.

This lack of understanding and failure to recognise the depth and breadth of our knowledges speaks to a wider deficit in truth-telling. Together we must work to continue to dismantle barriers and heal the psychological damage that colonisation and its continued circumstance inflicts on us all.

Recently, I put together an Aboriginal plant use booklet which speaks to my imperative to forefront our perspectives and ways of knowing in the urban context. I made the booklet for individuals, schools, kinder and community groups as way for people to connect with Aboriginal perspectives of plants.

This booklet encourages the use and appreciation of indigenous plants as well as providing an accessible portal through which a wide audience may begin to understand the complexity of our scientific practice.

It contains much information about resources for growing and exploring indigenous plants and has easily printable labels which people can put in their garden as a way to continue their learning journey.

Indigenous plants deliver a wide range of benefits. They are very hardy and require little water, which makes them sustainable and affordable to keep. They have evolved in local conditions, which adds to their hardiness and ability to survive. They tell stories about the cultural belonging of Indigenous peoples and allow a portal into our rich cultural and ecological knowledges.

They illuminate the specific identity and history of landscapes and provide much needed corridors and habitat for native animals, contributing significantly to healthy ecosystems.

They can be of benefit in mitigating soil erosion and water evaporation and require no fertilisers and little water. They are often medicinal, nutritionally beneficial and can be used to make many items, as well as providing colour and beauty to the landscape.

River Mint (*Mentha australis*). Photo: Alison Fong

The Indigenous plant use booklet is easily accessible and free for all. But within its generous offerings I seek reciprocity. I ask that we all take responsibility for educating ourselves about whose Country we are on and the deep knowledges held by Traditional Custodians.

I ask that we each educate ourselves not only on the beautiful and exciting aspects of our culture, but also on the issues which continue to catastrophically affect Aboriginal and Torres Strait Islander people today. It is only through Indigenous-led, long-term commitments that we can reawaken and reinvigorate knowledges.

Our interactions with Country both today and over time need illumination and are undoubtedly a key aspect of the breadth of scientific knowledge required to meet the many challenges we face.

But we must own our knowledges, we must lead organisations and projects which seek to interact with Indigenous knowledges or we risk repeating the mistakes of the past which have attested highly damaging and extractive modes of engagement.

It is only through working together and, most importantly, empowering Aboriginal and Torres Strait Islander leadership that we can all truly benefit from the breadth and depth of Indigenous knowledge.

Access the free booklet here: https://nespurban.edu.au/wp-content/uploads/2020/08/Indigenous-plant-use.pdf

The booklet is supported by the Clean Air and Urban Landscapes Hub, funded by the Australian Government's National Environmental Science Program.

"This article was first published on Pursuit.
Read the original article."
https://pursuit.unimelb.edu.au/

News and conferences

ANPC News

Progress towards revision of the ANPC's Germplasm Guidelines

The ANPC's best practice handbook for *ex situ* conservation is currently being revised, to produce the third edition of the publication '*Plant Germplasm Conservation in Australia – strategies and guidelines for developing, managing and utilising* ex situ *collections*'. Chapter working groups and case study authors, primarily in Australia and New Zealand, have been hard at work revising the existing content and including advances in our understanding and application of *ex situ* methods.

These existing chapters will have many new case studies and updated information on:

- Options and considerations for germplasm conservation.
- Seed and vegetative material collection.
- Seed banking.
- Seed germination and dormancy.
- Tissue culture.
- Cryopreservation.
- Living plant collections.

New chapters and case studies will be added with topics to cover:

- Genetic guidelines for acquiring and maintaining collections.
- Identifying and conserving non-orthodox species.
- The role of the nursery in *ex situ* conservation.
- Collection and storage of orchids and symbionts.
- Storage and maintenance of special collections such as pollen, spores and carnivorous plants.
- Risk management and crisis preparation, and
- Maintenance and utilisation of *ex situ* collections.

A review process with commence shortly, with internal review by chapter teams in 2020 and external review in early 2021. Anyone wishing to review the Germplasm Guidelines prior to publication is welcome to contact the Project Manager, see **https://www.anpc.asn.au/germplasm-guidelines-review/**.

As Project Manager, Germplasm Guidelines, Amelia Martyn Yenson would like to thank the contributors for their time and input during an especially challenging year. The revision is well-supported by the Germplasm Guidelines steering committee and funded by The Ian Potter Foundation.

The ANPC has been successful in applying for additional funding to hold an Australian Academy of Science Fenner Conference on the Environment in 2021/2022, during which an expert meeting associated with the Germplasm Guidelines revision will be held. The topic will be 'Exceptional Times, Exceptional Plants: *Ex situ* conservation strategies for Australian plants that cannot be conserved by conventional seed banking methods'. Stay tuned for more information!

Myrtle Rust – new National Action Plan

In 2018, *Myrtle Rust in Australia – a Draft Action Plan* was published, co-funded by the *Plant Biosecurity CRC* and the Commonwealth's *National Environmental Science Program*. The *Draft Action Plan* came from a process of expert workshops, analysis of literature, and consultation with researchers, field observers, and growers of Myrtaceae. That draft provided the first framework for a national response to the impacts of the pathogen on Australian native biodiversity.

Following submissions on the Draft plan (overwhelmingly supportive) and new developments on the Myrtle Rust front in Australia and internationally, a new and 'finalised' version of the Plan has been prepared, and published by the *Australian Plant Biosecurity Science Foundation*. The new *National Action Plan* (NAP) retains the same structure as the draft: five themes covering the human and biological/conservation requirements for an effective response, and a priority list of species. One species (*Rhodamnia maideniana*) has been upgraded to join the four already on the 'emergency' priority list.

Myrtle Rust in Australia – a National Action Plan is available for free download from **https://www.apbsf.org.au/apbsf-projects/**. That site also contains information on other Myrtle Rust projects funded by the APBSF.

The NAP is also mirrored, along with other Myrtle Rust resources, on the ANPC's Resources pages: **https://www.anpc.asn.au/myrtle-rust/**, where you can also find a one-page summary of the ANPC's own work on this issue since 2010.

Australia's response to the invasive Myrtle Rust pathogen continues to lag well behind that of New Zealand (**https://myrtlerust.org.nz/**) in investment and effort. We still lack any coordinating body, central information exchange, and an agency-endorsed plan. The draft plan, and now the NAP, have been driven by the community of practice around Myrtle Rust, to provide a common basis for action and to partially fill the gap left by the lack of a government-run national response. The Draft Plan helped shape a number of conservation action and research projects, and the 'finalised' NAP will do the same. The NAP has been sent to the Commonwealth Minister for the Environment, and her Department has advised that "the Government is considering options for how the National Action Plan can be incorporated into an effective response within the government system".

SAVE THE DATE: Australian Myrtle Rust National Symposium, March 2021

A national working group is preparing a National Symposium on Myrtle Rust, likely to be in the week beginning 23 March 2021. The virtual symposium will run over four days, with two 2-hour sessions per day. Sessions will cover *Impact Assessment* (actual field impacts, including a virtual field trip); *Towards Recovery* (perspectives for long- range species and ecosystem recovery); *Biosecurity* (keeping the pathogen out of SA and WA, and keeping other strains of the same disease out of the south-west Pacific); and *Awareness and Engagement*. The symposium's aim is to bring together conservation and plant health scientists, conservation managers and practitioners, and the wide range of stakeholders concerned about the disease, and take national coordination to a better level. There will be opportunities for both short (3 minute) and longer presentations, from invited and self-volunteered participants, and as much interaction as can be accommodated in a virtual format.

Watch the ANPC Myrtle Rust pages for further details as they become available: **https://www.anpc.asn.au/myrtle- rust/**, or contact bobmakinson2073@gmail.com for further information in the meantime.

Preventing extinction in bushfire affected orchids

The ANPC is proud to be involved in a new project helping to conserve 14 nationally threatened orchid species across three states. The orchids were affected by the 2019-20 fires at Kangaroo Island, East Gippsland and the Australian Alps. Project leaders Dr Noushka Reiter, Dr Ryan Philips and Dan Duval will work with volunteers and partner organisations to prevent extinction of these species through seed collection, propagation and research on post fire herbivory and reproduction. A symposium will be held in 2021 to share the project's results and provide a networking opportunity for the orchid conservation community. Funding for this project was provided by the Australian Government's Wildlife and Habitat Bushfire Recovery Program. Head to the ANPC's project website to find out more. **https://www.anpc.asn.au/projects/preventing-extinction-in-bushfire-affected-orchids/**

Florabank Guidelines update

The update of the Florabank Guidelines is progressing well, with 13 modules now back from review, one module still in review, and one module in the final stages of drafting. The next step is to address the reviews, collate the images, and finalise the drafts for layout. We anticipate that the Guidelines will be launched in the first half of 2021. Plans for workshops are on hold given current travel restrictions, but stay tuned for possible online opportunities to learn about the Guidelines. A large number of people from Australia and across the world have been involved in writing, editing and reviewing. ANPC Project Manager Lucy Commander would like to thank all those involved thus far. Please contact Lucy if you would like to have any input before the final stages of production. Thanks to the NSW Environmental Trust for funding the Healthy Seeds project, which includes the Guidelines update.
https://www.anpc.asn.au/florabank/

ANPC Annual General Meeting held Wednesday 11 November 2020

The Annual General Meeting of the Australian Network for Plant Conservation Inc. (ANPC) was held on Wednesday 11 November 2020 over Zoom. We thanked Dr Melissa Millar who finished her term as Secretary and was then elected as an ordinary member. We said thank you and farewell to our committee members Dr Cathy Offord and Chantelle Doyle who have finished their terms. We welcomed Andrew Fairney and Dr Meredith Cosgrove as new Ordinary Members of the ANPC Management Committee and thank them for their nominations. We also welcomed a new Treasurer, Grant Warner.

Have you considered joining the committee of Australia's only national plant conservation network? The ANPC is looking for a Secretary. You can make a difference in promoting and improving plant conservation in Australia! Download the Nomination Form here
https://www.anpc.asn.au/events-cat/anpc-annual-general-meeting-wednesday-11-november-2020/

Plant conservation and fire

In the Spring 2020 edition of the Australian Wildlife Magazine you will find an article penned by the ANPC's president Dr Tony Auld, APC editor Dr Heidi Zimmer and one of the ANPC's project managers, Dr Lucy Commander. Based on their article in the March-May 2020 issue of Australasian Plant Conservation, this article considers how fire influences our approaches to plant conservation and the challenges that a changing climate brings.
https://search.informit.com.au/documentSummary;dn=194379174791994;res=IELHSS

APCC13 postponed to April 2022

The organising committee has made the difficult decision to postpone the 13th Australasian Plant Conservation Conference (APCC13) which was scheduled for 19 to 23 April 2021. This decision was made based on the changing travel restrictions and social distancing measures which affect the organisation of and participation at this event. When deciding to postpone the conference we considered various other formats but opted for a physical conference. This ensures the in-person networking opportunities this event provides are not constrained by social distancing or a virtual format. The theme for the APCC13 conference is 'Seeds to Recovery'. A call for abstracts will be announced in 2021 with more information to be made available closer to the event on our website. We'd like to thank our sponsors and partners for their ongoing support. We look forward to seeing you in 2022!
https://www.anpc.asn.au/conferences/apcc13/

13th Australasian Plant Conservation Conference 2022

Project Phoenix

ANPC Project Managers, Martin Driver and Lucy Commander will be using their expertise to help with the fire recovery efforts through Project Phoenix: native seed for bushfire recovery. Greening Australia is leading this strategic program to build and secure native seed and plant supply for restoration after the devastating Black Summer bushfires. Learn more here:
https://www.greeningaustralia.org.au/projects/projectphoenix/

Greening Australia

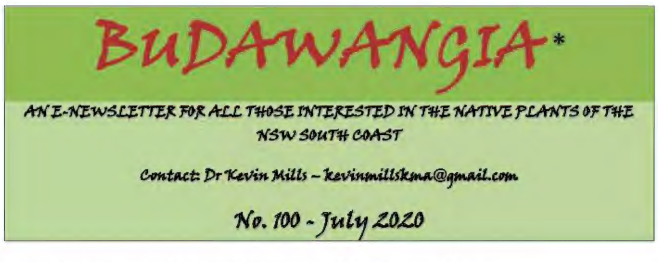
Dr Cathy Offord on The Year That Made Me

The ANPC's committee member Dr Cathy Offord featured in ABC Radio National's show The Year That Made Me. Cathy chose to talk about 1994, in this chat she discusses the discovery of the Wollemi Pine, her contribution to its conservation and her botanical wedding. She also talks about a project with the APC's editor Dr Heidi Zimmer. **https://www.abc.net.au/radionational/programs/sundayextra/the-year-that-made-me:-cathy-offord/12668748**

Dr Cathy Offord.

Budawangia publishes 100th edition

Long time member of the ANPC, Dr Kevin Mills produces the e-newsletter 'Budawangia' for those interested in the native plants of the NSW South Coast. Kevin has recently published the 100th edition of Budawangia. Since its launch in 2012 this e-newsletter has discussed hundreds of local plant species to connect those interested in native flora of the Illawarra region and NSW South Coast. If you would like to subscribe to the e-newsletter please send Kevin an email (kevinmillskma@gmail.com).



Header from Budawangia, created by Kevin Mills.

Saving the brilliant sun orchid (*Thelymitra mackibbinii*) from extinction

The ANPC is working with Royal Botanic Gardens Victoria, Friends of Grampians Gariwerd – FOGGS and Australasian Native Orchid Society – Victorian Group to save the threatened *Thelymitra mackibbinii* from extinction, thanks to funding from the Department of Environment, Land, Water and Planning. *Thelymitra mackibbinii* has less than 60 naturally wild plants remaining in the Wimmera district of Victoria. So far, two exclusion fences have been constructed to protect plants from grazing kangaroos, wallabies and rabbits. Surveys for any new plants and to identify the species' pollinator (a native bee) have also been undertaken by community volunteers. Further surveys and pollinator baiting will be undertaken this Spring, before re-introducing 400 seedlings in winter 2021. **https://www.anpc.asn.au/brilliant_sun-orchid/**

Brilliant Sun Orchid (*Thelymitra mackibbinii*). Photo: Noushka Reiter

Plant cuttings – plant conservation news from around Australia

Editors' note: News excerpts are clipped from a diversity of sources. To read the articles in full follow the links attached to each clipping. The views expressed in these articles are those of their authors and do not necessarily represent the opinion of the ANPC.

Native seed collection and propagation the next boom industry, researcher says

The native seed collection and propagation industry represents one of the "most wonderful business and economic opportunities" for traditional owners in the country, researchers have said, with demand for land restoration projects rapidly increasing. The native seed industry is relatively small in Australia, made up primarily of a small group of individuals and businesses in each state. But researchers say there has been a "paradigm shift" in the need and appreciation for restoring degraded land and industry now needs to grow to meet it.
https://www.abc.net.au/news/2020-10-09/native-seed-collection-and-propagation-the-next-boom-industry/12733242

Final National prioritisation of Australian plants affected by the 2019-2020 bushfire season

The *Final National prioritisation of Australian plants affected by the 2019-20 bushfire season*, released on 13 October 2020, updates the Interim Assessment released by the Wildlife and Threatened Species Bushfire Recovery Expert Panel on 23 April 2020. The Interim Assessment identified 471 plant species identified as the highest priorities for urgent management intervention to support recovery from the 2019-20 bushfires. The revised list now includes 486 species prioritised as requiring immediate action to assess impacts and support recovery.
https://www.environment.gov.au/biodiversity/bushfire-recovery/priority-plants

Academy Fellows say it's time to establish an independent biodiversity agency

With Australia failing to halt species decline and our biodiversity management systems broken, now is the time to establish a new independent agency to manage our nation's biodiversity data, according to Australia's leading scientists. The recommendation by the Australian Academy of Science is part of a brief that has been sent to all Australian MPs and senators ahead of debate, expected in the Senate in November, on the Australian Government's Environment Protection and Biodiversity Conservation Amendment (Streamlining Environmental Approvals) Bill 2020.
https://www.science.org.au/news-and-events/news-and-media-releases/academy-fellows-time-establish-independent-biodiversity-agency

Collaboration leads to rare plant translocation

Two years of work to return the "flower of the underworld" to Wellington culminated this week, with Pua o te Rēinga/*Dactylanthus taylorii* seed making its way from Pureora Forest Park to Wellington's Otari-Wilton's Bush. Pua o te Rēinga, te reo Māori for "flower of the underworld", is an unusual parasitic plant which grows as a tuber attached to the root of a host tree. Specimens of the root connection and the plant itself are sometimes also called woodrose.The species is currently regarded as being in serious decline, and the Department of Conservation (DOC) has a recovery plan to ensure its survival. Threats include pest animals such as possums and pigs, habitat loss and it being dug up by people. The plant also relies on native bats and some birds for its pollination and seed distribution so threats to these species have a knock-on impact on dactylanthus.
https://www.doc.govt.nz/news/media-releases/2020-media-releases/collaboration-leads-to-rare-plant-translocation/?utm_source=miragenews&utm_medium=miragenews&utm_campaign=news

89yo orchid hunter still loves searching for Mother Nature's treasures

When Ray Garstone is on the hunt for orchids, the 89-year-old moves through the bush like a person half his age. The retired Great Southern farmer has looked for orchids since his childhood and been photographing them for 30 years. Armed with his trusty camera and binoculars, Mr Garstone is also an enthusiastic bird watcher and lover of wildflowers in general. "Seeing the bush in its natural state is one of life's greatest pleasures," he said.

https://www.abc.net.au/news/2020-10-15/orchid-hunter-ray-garstone-loves-getting-out-in-nature/12767182

National park funding for fire recovery

Five new projects will be rolled out to support the recovery of bushfire affected wildlife and habitat including seed collecting and vegetation surveys to help prevent plant extinction. More than $1.1 million under the second round of the government's wildlife and habitat bushfire recovery program will focus on conducting fieldwork surveys to assess the impact of the bushfires on threatened species, while seed collecting and vegetation surveys will help prevent extinction and limit the decline of priority plants.

https://www.bluemountainsgazette.com.au/story/6969897/bushfire-recovery-funding-for-the-mountains/

Famous Aussie wildflower gets its own garden

The Australia National Botanic Gardens is celebrating its 50th anniversary with the official opening of one of the largest gardens in Australia dedicated to a national symbol of biodiversity - the native banksia wildflower. Using cutting edge grafting technology, staff established a 2500 square metre garden that required the construction of thermal walls to shield plants from Canberra's chill and to absorb and radiate heat from the winter sun. Minister for the Environment Sussan Ley said the banksia is one our most iconic plant species and it is fitting that it now takes pride of place among the largest collection of Australian native plants in the world.

https://minister.awe.gov.au/ley/media-releases/famous-aussie-flower-gets-own-garden?utm_source=miragenews&utm_medium=miragenews&utm_campaign=news

AIATSIS code of ethics published

AIATSIS published the *AIATSIS Code of Ethics for Aboriginal and Torres Strait Islander Research* (the AIATSIS Code). This document supersedes and replaces the *AIATSIS Guidelines for Ethical Research in Australian Indigenous Studies*2012 (GERAIS). All references to GERAIS in Australian research codes and guidance should be taken to refer to this Code. The release of the AIATSIS Code will see a 12-month implementation period. Other supporting resources and templates will be developed and published during the implementation period and beyond. The AIATSIS code can be downloaded here:

https://aiatsis.gov.au/research/ethical-research/code-ethics

Food, tools and medicine: 5 native plants that illuminate deep Aboriginal knowledge

Over countless millennia, Aboriginal and Torres Strait Islander peoples have harnessed the tremendous potential of plants, ingeniously using them for medicines, nutrition, to express our culture and to develop innovative technologies. But as I learn more about First Peoples' plant knowledge, I'm also better understanding the broader Australian community's failure to recognise the depth and breadth of our expertise.

https://theconversation.com/food-tools-and-medicine-5-native-plants-that-illuminate-deep-aboriginal-knowledge-145240

Queensland investigates suspected clearing of critically endangered black grevillea

Queensland environment authorities say they are investigating the suspected illegal clearing of a "significant portion" of a critically endangered plant species in the state's Granite Belt region. The plant, black grevillea, was listed as "critically endangered" by the Queensland government last year after a submission from a local conservation group. The known world population of the plant is 1,449 mature plants. The group that championed the listing, the Stanthorpe Rare Wildflower Consortium, last week discovered an estimated 300 plants cleared at two sites.

https://www.theguardian.com/australia-news/2020/oct/22/queensland-investigates-suspected-clearing-of-critically-endangered-black-grevillea

The fungus-eating Bussell's spider orchid is being brought back from the brink

In 2017, there were just four known specimens of the Bussell's spider orchid alive in Western Australia's bushland. The critically endangered orchids, officially known as Caladenia busselliana, only grow in a 40-kilometre stretch of the Leeuwin Naturaliste Ridge in the state's south west. Belinda Davis, orchid conservation research scientist at Kings Park, was called in to help bring the species back from the brink of extinction.
https://www.abc.net.au/news/2020-10-24/bringing-the-bussells-spider-orchid-back-from-the-brink/12784110

State of the World's Plants and Fungi

Jonathan Green discusses a new report assessing the health of the worlds plants and fungi that delivers grim findings and explores how plant and fungal diversity can be protected in future.
https://www.abc.net.au/radionational/programs/blueprintforliving/state-of-the-worlds-plants-and-fungi/12797346

More support in the battle against established pest animals and weeds

The Australian Government is continuing to support the fight against established pest animals and weeds with $3.5 million in funding for a range of new research and development projects. Minister for Agriculture, Drought and Emergency Management, David Littleproud, said the projects look at important tools for farmers and landowners including potential new herbicides, fireweed biocontrol, better understanding of feral pig populations, more effective pest animal detection technologies and coordination of feral deer control.
https://minister.awe.gov.au/littleproud/media-releases/%243.5m-established-pests-weeds

Tumby Bay's threatened Whibley wattle offered chance of survival with rotary hoe digging trial

There is new hope for one of Australia's most endangered acacias, with South Australian researchers trialing an innovative technique to produce more of the much-loved Whibley wattle. The Whibley wattle is a protected native species and regarded as one of Australia's highest and most urgent national conservation priorities. It can only be found in one area globally, at SA's Tumby Bay on the south-east of the Eyre Peninsula, and many adult shrubs die before their seeds germinate.
https://www.abc.net.au/news/2020-09-10/threatened-tumby-bay-whibley-wattle/12649278.

Research finds nearly all of protected habitats are 'disconnected'

More than 90 per cent of the world's protected wildlife habitats are "disconnected", new research has found, greatly reducing their ability to support the plants and wildlife they were established to protect. Most nations on Earth have established protected areas to help conserve wildlife and plant species and maintain a functional ecosystem. However, an analysis of the world's protected areas by researchers from the University of Queensland's School of Earth and Environmental Sciences found that the vast majority of these areas are isolated from each other, decreasing their usefulness.
https://www.brisbanetimes.com.au/national/queensland/research-finds-nearly-all-of-protected-habitats-are-disconnected-20200911-p55uub.html

To protect this rare underground orchid, researchers are keeping its location top secret

Maree Elliott admitted feeling a bit despondent as she poked around the leaf litter in the Barrington Tops National Park north of Newcastle four years ago. Ms Elliott, a scientific illustrator, had been looking for a native fungi to draw for her work, but despite hours of searching the 65-year-old retiree was having no luck. What she stumbled on instead would rewrite scientific literature.
https://www.abc.net.au/news/2020-09-13/new-underground-orchid-flower-find-thrills-botanists/12656410

Plant Conservation Report 2020 Launched

On 15 September, the Plant Conservation Report - a Review of Progress in Implementation of the Global Strategy for Plant Conservation 2011-2020 was launched alongside the 5th edition of the Global Biodiversity Outlook. This report is based on information provided by members of the Global Partnership for Plant Conservation as well national reports from countries submitted as part of 6th National Reports to the Convention on Biological Diversity.
https://plants2020.net/news/1555/

Native stinging tree toxins match the pain of spiders and cone snails

The painful toxins wielded by a giant Australian stinging tree are surprisingly similar to the toxins found in spiders and cone snails, University of Queensland researchers have found.The Gympie-Gympie stinging tree is one of the world's most venomous plants and causes extreme long-lasting pain. Associate Professor Irina Vetter, Dr Thomas Durek and their teams at UQ's Institute for Molecular Bioscience found a new family of toxins, which they've named 'gympietides' after the Gympie-Gympie stinging tree.
https://www.uq.edu.au/news/article/2020/09/native-stinging-tree-toxins-match-pain-of-spiders-and-cone-snails

Freesias, daisies and other 'beautiful' pests threaten native wildflowers in Wanilla Conservation Park

Wanilla Conservation Park, 36 kilometres north-west of Port Lincoln, is a tiny drop of protected land in a vast ocean of agricultural country. Right now wildflowers are blooming among a large variety of native Australian plants as spring brings warmer temperatures to the Eyre Peninsula of South Australia.Wildflower enthusiast and author Janet Smyth visits the conservation park often and says there is a creeping threat encroaching on the protected area.
https://www.abc.net.au/news/2020-09-22/beautiful-pests-wanilla-conservation-park-wildflowers/12689290

National Seed Bank set to expand to new facility to continue work protecting native plants

[only accessible to Canberra Times subscribers]
https://www.canberratimes.com.au/story/6929448/the-critical-work-saving-canberras-native-plants-from-bushfire-extinction/

We accidentally found a whole new genus of Australian daisies. You've probably seen them on your bushwalks

When it comes to new botanical discoveries, one might imagine it's done by trudging around a remote tropical rainforest. Certainly, that does still happen. But sometimes seemingly familiar plants close to home hold unexpected surprises. We recently discovered a new genus of Australian daisies, which we've named Scapisenecio. And we did so on the computer screen, during what was meant to be a routine analysis to test a biocontrol agent against a noxious weed originally from South Africa.
https://theconversation.com/we-accidentally-found-a-whole-new-genus-of-australian-daisies-youve-probably-seen-them-on-your-bushwalks-139754

NZ's most prestigious conservation award – Loder Cup presented to Graeme Atkins

"Graeme Atkins of Ngāti Porou is a Department of Conservation ranger whose contribution to conservation goes well above and beyond his employment," said Eugenie Sage.The Loder Cup was first donated in 1926 to encourage and honour New Zealanders who work to investigate, promote, retain and cherish our indigenous flora; this ethos resonates throughout Graeme's life and work.
https://www.doc.govt.nz/news/media-releases/2020-media-releases/nzs-most-prestigious-conservation-award--loder-cup-presented-to-graeme-atkins/?utm_source=miragenews&utm_medium=miragenews&utm_campaign=news

E-greening the planet

This short piece details Ant Forest, a Chinese initiative that encourages users to record their low-carbon footprint through daily actions like taking public transport or paying utility bills online. For each action, they receive 'green energy' points and when they accumulate a certain number of points, an actual tree is planted.
https://www.researchgate.net/publication/344310708_E-greening_the_planet

Australian Institute of Botanical Science

The newly created Australian Institute of Botanical Science will merge a range of physical and virtual scientific collections, research, services, facilities and staff from the Royal Botanic Garden Sydney, Australian Botanic Garden Mount Annan and the Blue Mountains Botanic Garden Mount Tomah. The new Institute aims to advance fundamental knowledge of flora, and drive conservation solutions that ensure the survival of plants and build resilient ecosystems for future generations.
https://www.rbgsyd.nsw.gov.au/stories/2020/the-australian-institute-of-botanical-science

Parks Australia safeguards rare tree from local extinction

Cuttings taken from a critically endangered tree species by Parks Australia staff just months before the Black Summer bushfires are highlighting the importance of ongoing Morrison Government strategies to restore native habitat as part of its $200 million bushfire wildlife and habitat recovery funding. Staff at Parks Australia protect and conserve thousands of native species, including some of our most threatened plant species such as the Banksia vincentia, magenta lilly pilly and Kakadu hibiscus.
https://minister.awe.gov.au/ley/media-releases/parks-australia-safeguards-rare-tree-local-extinction

National Parks and Wildlife carry out pest removal to help native plants and animals recover from bushfires

Efforts continue to remove pests from the Abercrombie River, Kanangara Boyd and surrounding national parks to help native plants and animals recover from last summer's bushfires. The operation removed 55 goats, pig and deer from the Abercrombie Karst Conservation Reserve which is home to the only known population of *Bossiaea fragrans*."*Bossiaea fragrans*, a pretty yellow-flowering shrub is a critically endangered species with only a handful of plants remaining in the wild," Ms Lonergan said.
https://www.lithgowmercury.com.au/story/6860706/deer-foxes-goats-and-wild-pigs-removed-for-fire-recovery/

Science stimulates rare tree surge

The population of a critically endangered plant species only found on the NSW north coast has leapt from 10 to more than 1500 trees in just a decade. SoS Senior Threatened Species Project Officer Dianne Brown said thanks to clear-thinking scientists, NSW Government funding and the community, *Coastal Fontainea* now has a far better chance of surviving. "In 2010 we had just 10 adult trees left – only one of which was female – and genetic testing on the seedlings showed inbreeding. Safeguarding Coastal Fontainea's future was critical," she said.
https://www.environment.nsw.gov.au/news/science-stimulates-rare-tree-surge

'Miracles in our own backyards': Rare urban ecosystems on the brink

Almost half of Australia's national-listed threatened animals and a quarter of the plant species at risk are found in the largest towns and cities, and the threats are intensifying. That's the findings of an analysis of known locations of at-risk forest species in towns with 10,000 people or more by the Australian Conservation Foundation. It excluded grassland or marine habitats and assessed habitat destruction only up to 2017.
https://www.smh.com.au/environment/conservation/miracles-in-our-own-backyards-rare-urban-ecosystems-on-the-brink-20200804-p55ifq.html

'Paradise island' hosts untold botanical treasures

New Guinea has the highest plant diversity of any island in the world, botanists have discovered.The first full inventory of plants on the world's largest tropical island reveals a treasure trove of flora.More than 13,000 species can be found on New Guinea, ranging from tiny orchids to giant tree ferns, two-thirds of which do not exist elsewhere.The findings, published in Nature, will be used to protect "one of the last unknowns for science".
https://www.bbc.com/news/science-environment-53668124

Native wildflower boom during COVID-19 pandemic

When the COVID-19 pandemic tightened its grip on the global flower industry, West Australian-based sheep and wildflower farmers Clive and Maureen Tonkin changed their business from export focussed to instead servicing the domestic market. "We're still handling the same product, it's just that none of it is going overseas, it's all going locally," Mr Tonkin said.The Tonkins have been harvesting native flowers at their Moora farm for the past 45 years."Its taken a long time to get Australian florists to use Australian flowers — it's good to see," Mr Tonkin said.
https://www.abc.net.au/news/2020-08-06/boom-in-native-flowers-grows-during-covid-pandemic/12519474

A genetic helping hand for our native trees

At Nardoo Hills, like many parts of Australia, the climate is changing faster than the native plants and animals can adjust. The caretakers at Nardoo Hills, a 1000-hectare grassy woodland conservation reserve in northern Victoria, noticed the grey box and yellow box eucalyptus trees were losing their canopies and dying. Over the past decade, about 100 hectares of these two species of eucalypts have died at the reserve as a result of intense periods of hotter, drier weather. This has spurred Bush Heritage to embark on a long-term climate change adaptation experiment, which will take place over the next 70 years and more.
https://www.smh.com.au/environment/climate-change/a-genetic-helping-hand-for-our-native-trees-20200808-p55jsk.html

A rare native, Hibiscus richardsonii, has been discovered on a burnt headland at Malua Bay

A native plant rarely seen before has risen from the ashes following the summer bushfires. Eurobodalla Council's environment team has been monitoring 14 sites across the shire to record the recovery of vegetation and monitor weeds. Consultant botanist Jackie Miles said the returning vegetation was a mixture of post-disturbance colonisers, which disappear once normal vegetation returns, and plants that formerly occupied the sites.
https://www.naroomanewsonline.com.au/story/6874322/rare-native-plant-discovered-in-the-eurobodalla-post-fires/?cs=12

'Majestic, stunning, intriguing and bizarre': New Guinea has 13,634 species of plants, and these are some of our favourites

Scientists have been interested in the flora of New Guinea since the 17th century, but formal knowledge of the tropical island's diversity has remained limited. To solve this mystery, our global team of 99 scientists from 56 institutions built the first ever expert-verified checklist to the region's vascular plants (those with conductive tissue). We found there are 13,634 formally described species of plants in New Guinea, of which a remarkable 68% are known to occur there and nowhere else. This richness trumps both Madagascar (11,488 species) and Borneo (11,165 species), making New Guinea the most floristically diverse island in the world.
https://theconversation.com/majestic-stunning-intriguing-and-bizarre-new-guinea-has-13-634-species-of-plants-and-these-are-some-of-our-favourites-144279

6 reasons kids should take part in the Sydney Science Trail

As Sydney Science Trail prepares to launch on Saturday 15 August, Dr Brett Summerell shares with parents the reasons why exposure to science is so critical and healthy. Science Week is a great way for kids to get an intensive snapshot of why science is important and relevant to their future. As part of the Sydney Science Trail, kids can grab all sort of aspects and see how they are all interrelated. They can see why nature is essential and why it is important to understand the science behind nature. Pretty quickly they can see how it all interconnects and how important it is to our future survival on the planet.
https://www.rbgsyd.nsw.gov.au/Stories/2020/6-reasons-kids-should-take-part-in-Sydney-Science-

Eurardy Nature Reserve transforms from former pastoral station with one million trees

Soar high above Western Australia's northern agricultural land and you'll see field upon field of crops stretching to the horizon below. It's not until you reach the boundaries of the 33,000-hectare Eurardy Nature Reserve, 145 kilometres north of Geraldton in WA's Midwest, that the land begins to change. Most of this former pastoral station remains uncleared, offering an island of native vegetation among a sea of farmland. Yet the property's 100-year pastoral history did take its toll on the land, with about 3,000 hectares cleared for stock and cropping. Now, a husband and wife team working for Bush Heritage Australia has embarked on an ambitious project to plant one million trees over 10 years to help restore 1,300 hectares of cleared land.
https://www.abc.net.au/news/2020-08-14/eurardy-nature-reserve-aims-for-one-million-trees/12549300

Tree ferns are older than dinosaurs. And that's not even the most interesting thing about them

With massive fronds creating a luxuriously green canopy in the understory of Australian forests, tree ferns are a familiar sight on many long drives or bushwalks. But how much do you really know about them? First of all, tree ferns are ferns, but they are not really trees. To be a tree, a plant must be woody (undergo secondary plant growth, which thickens stems and roots) and grow to a height of at least three metres when mature. While tree ferns can have single, thick trunk-like stems and can grow to a height of more than 15 metres, they are never woody.
https://theconversation.com/tree-ferns-are-older-than-dinosaurs-and-thats-not-even-the-most-interesting-thing-about-them-138435

Help name our lesser-known threatened species

Saving our Species recently opened submissions for the public to name eight of NSW's lesser-known threatened species.173 of our most beautiful and unique native species are known only by their scientific names, which are hard to pronounce and even trickier to remember. That's why we want you to suggest catchy names for 8 unnamed, but not unloved, threatened species found in NSW, from orchids to wattle. Winners will be announced on Threatened Species Day, 7 September 2020.
https://www.environment.nsw.gov.au/news/help-name-our-lesser-known-threatened-species

Plants take in less carbon in a warming world

As world temperatures rise, the rate at which plants in certain regions can absorb carbon dioxide is declining, according to University of Queensland research. Over a three year period, researchers took direct measurements of plant absorption of CO2 in subtropical coastal ecosystems in eastern Australia. Professor Hamish McGowan, from UQ's School of Earth and Environmental Sciences, said the team found the optimum temperature for photosynthetic production was routinely exceeded in these regions. "Plants' optimum temperature range for photosynthesis in our study area is between 24.1 and 27.4 degrees Celsius," Professor McGowan said. "But due to anthropogenic climate change, temperatures – particularly in warmer months – often go well beyond this 'healthy' range for carbon absorption.
https://www.uq.edu.au/news/article/2020/08/plants-take-less-carbon-warming-world

Illustrating the importance of Target 16: Australian networks delivering towards the global strategy for plant conservation

The conservation of native flora is for many individuals a lifelong endeavour, requiring much collaboration, knowledge sharing and in-kind support. Botanic gardens are no exception with networks and partnerships critical to many conservation and research projects. The Council of Heads of Australian Botanic Gardens (CHABG) is one of Australia's many botanical networks, representing the major capital city botanic gardens in each state and territory. For the past two decades the CHABG has supported both *in situ* and *ex situ* conservation outcomes for Australian flora through botanic gardens and seed banks with the help of numerous project collaborators and partners. Now more than ever this national network of like-minded conservation institutions is playing a critical role in supporting the delivery of the Global Strategy for Plant Conservation as Australia responds to the recent catastrophic bushfires.
https://www.bgci.org/wp/wp-content/uploads/2020/08/BGjournal17.2.pdf

Other conferences, courses and events

Updates available at
http://anpc.asn.au/other_conferences_and_events

Skills impact calling for feedback on plant related education

Those with experience working in parks and gardens and others with knowledge in this field who are able to describe the skills and qualifications needed for this industry are invited to engage with this project. It is important that training provides a skilled and flexible workforce for the future. The qualifications, skill sets, and units need to reflect real work experience. So, if you work in the sector, Skills Impact welcomes your input and assistance. The skills standards will be drafted in consultation with Subject Matter Experts and their networks. Opportunities to provide targeted feedback will occur when the draft skills standards are made available in Nov-Dec 2020, and again for validation of final drafts in Mar-Apr 2021. However, your feedback is welcomed at any time, and will help us in drafting the qualifications, skill set and units.
https://www.skillsimpact.com.au/horticulture-conservation-and-land-management/training-package-projects/parks-gardens-project/?_cldee=ZmxvcmFiYW5rQGFucGMuYXNuLmF1&recipientid=contact-dd90aaedbb1cea11a811000d3a797268-bd6337037a3a494e80d197b6406f3f9e&esid=b52198a5-fd0c-eb11-a813-000d3a797268

Virtual Science Seminars - The Royal Botanic Garden Sydney

The Royal Botanic Garden Sydney science seminars are now virtual. The latest presentation was given by Santiago Ramírez Barahona whose talk is titled 'The delayed rise of angiosperms'.
https://www.rbgsyd.nsw.gov.au/Science/Virtual-science-seminars

State of the World's Plants and Fungi Virtual Symposium - Royal Botanic Gardens Kew, recorded talks

If you missed the virtual symposium held in mid-October you can now watch the talks on You Tube by following the links on the Royal Botanic Gardens Kew webpage.
https://www.kew.org/science/engage/get-involved/conferences/state-of-the-worlds-plants-and-fungi-symposium.

Agriculture Research Showcase - The University of Sydney Institute of Agriculture

The 2020 Sydney Institute of Agriculture Research Showcase was held on Wednesday 7 October 2020 as an online webinar. The theme for this year's research showcase was Plant Health as the United Nations General Assembly declared 2020 as the **International Year of Plant Health** (IYPH). Recordings of the Showcase are available form the University of Sydney's website.
https://www.sydney.edu.au/agriculture/outreach-engagement/annual-research-symposium.html

Landcare Checks In - WA Landcare Network fortnightly Zoom sessions

'Landcare Checks In' is WA Landcare Network's new online opportunity for landcarers to come together to chat about landcare issues. This provides a platform for land carers to come together to discuss a range of landcare hot topics. Each fortnight a different discussion topic is chosen based on input from participants. Recordings of previous sessions can be found on the WA Landcare website.
http://www.landcarewa.org.au/resources/landcare-checks-in-online-chat-about-landcare/

2020 Environmental biosecurity webinars - Department of Agriculture, Water and the Environment

From July to November 2020 the Chief Environmental Biosecurity Officer hosted a webinar in the last week of each month. Each webinar explored a different theme, with 3-4 speakers discussing their views and involvement in environmental biosecurity. Recordings of the webinars can be found on the Department of Agriculture, Water and the Environment website.
https://haveyoursay.awe.gov.au/2020-environmental-biosecurity-webinars

Saving our rainforests from fire - Big Scrub Landcare webinars available online

Last year the Big Scrub Rainforest Day went online, providing greater opportunity for people to get involved. The two panel discussions were facilitated by well-known ABC journalists Kerry O'Brien and Mick O'Regan. These focused on the bushfires in and around Nightcap National Park and their impact on Gondwana and lowland subtropical rainforests. The webinars are available online and include a panel discussion on the impacts and lessons learned during the 2019-2020 Nightcap bushfires, an analysis feature by botanist Nan Nicholson and a panel discussion on actions to reduce the impacts of future bushfires on our rainforests.
https://www.bigscrubrainforest.org/panel-discussions/

Council Roadside Reserves Training - Local Government NSW

Four modules of free online training can be accessed to learn more about managing roadside reserves. The Council Roadside Reserves Project, funded by the NSW Environmental Trust and was developed to build the capacity of NSW councils to improve the management of roadside environmental values and to integrate their management into existing council plans and operations. Developed specifically for councils to guide them through the complexities of roadside reserve management, these four e-learning modules will raise learners' awareness of their responsibilities when it comes to managing and working in the road reserve and ensuring roadside environmental management best practice.
https://lgnsw.org.au/Public/Public/Policy/REM-pages/CRR_training.aspx

Recovering after bushfires - what role can Landcare play? - Landcarer

Chris Cobern from the Upper Goulburn Landcare Network in Victoria was heavily involved in the recovery efforts following the Black Saturday bushfires in 2009. He worked with local communities, government, and volunteers for many years to help the landscape heal and recover. In this webinar recording Chris chats about how he navigated issues around sourcing funding and volunteers, providing training, supporting local landholders, and what he's learnt that can help groups and organisations working in similar circumstances today. Chris was joined by Landcare Australia's Rowan Ewing, who gave an update on our bushfire recovery fund activities to date, and what's planned for the coming months.
https://www.landcarer.com.au/recovering-after-bushfires-webinar/?fbclid=IwAR2YHkGa14uYlcR11VeKQ2CmLda_iZ0CXS94COMuJjW3TtxyXQhpJCXhL5A

Our Knowledge, Our Way guidelines launch - CSIRO webinar recording

Indigenous Australians rights of ownership and management have been recognised over nearly half of Australia and their knowledge systems connect them to their Country and cultures.The *Our Knowledge Our Way* in caring for Country Best Practice Guidelines, gives a voice to Indigenous land and sea managers who have found good ways to strengthen their knowledge and build partnerships for knowledge sharing in caring for Country.
https://www.csiro.au/en/Research/LWF/Areas/Pathways/Sustainable-Indigenous/Our-Knowledge-Our-Way

Climate Change, Fire, and Biodiversity webinar series - Threatened Species Recovery Hub

Catch up on this webinar series produced by the Threatened Species Recovery Hub. The latest webinar recorded on August 25 is titled 'Lessons from the fires: A biodiversity and climate perspective'. This 1.5 hour webinar brings together perspectives from biodiversity and climate change experts and policy makers. It focuses on understanding bushfire seasons under a changing climate, preparedness for future bushfire seasons and ongoing impacts on biodiversity.
https://www.nespthreatenedspecies.edu.au/events/climate-change-fire-and-biodiversity-webinar-series

Research round up

COMPILED BY TOM LE BRETON

University of New South Wales.

Abrahams, J. (2020). **The extinction crisis in Australia's cities and towns**. *Planning News*, 46(8):16. https://search.informit.com.au/fullText;dn=387025464630524;res=IELBUS

Adade Williams, P., Sikutshwa, L. and Shackleton, S. (2020). **Acknowledging indigenous and local knowledge to facilitate collaboration in landscape approaches—lessons from a systematic review**. *Land*, 9(9):331. https://doi.org/10.3390/land9090331

Aslan, C.E. and Dickson, B.G. (2020). **Non-native plants exert strong but under-studied influence on fire dynamics**. *NeoBiota*, 61:47-64. https://doi.org/10.3897/neobiota.61.51141

Bell-James, J., Boardman, T. and Foster, R. (2020). **Can't see the (mangrove) forest for the trees: Trends in the legal and policy recognition of mangrove and coastal wetland ecosystem services in Australia**. *Ecosystem Services*, 45:101148. https://doi.org/10.1016/j.ecoser.2020.101148

Blyth, C., Christmas, M.J., Bickerton, D.C., Faast, R., Packer, J.G., Lowe, A.J. and Breed, M.F. (2020). **Increased genetic diversity via gene flow provides hope for *Acacia whibleyana*, an Endangered wattle facing extinction**. *Diversity*, 12(8):299. https://doi.org/10.3390/d12080299

Bolch, E.A., Santos, M.J., Ade, C., Khanna, S., Basinger, N.T., Reader, M.O. and Hestir, E.L. (2020) **Remote detection of invasive alien species**. In: Cavender-Bares J., Gamon J., Townsend P. (eds) *Remote Sensing of Plant Biodiversity*. Springer, Cham. https://doi.org/10.1007/978-3-030-33157-3_12

Burgess, M.D., Eaton, M.A. and Gregory, R.D. (2020). **A review of spatial patterns across species ranges to aid the targeting of conservation interventions**. *Biological Conservation*, 251:108755. https://doi.org/10.1016/j.biocon.2020.108755

Buxton, R.T., Avery-Gomm, S., Lin, H.Y., Smith, P.A., Cooke, S.J. and Bennett, J.R. (2020). **Half of resources in threatened species conservation plans are allocated to research and monitoring**. *Nature Communications*, 11(1):1-8. https://doi.org/10.1038/s41467-020-18486-6

Carlson, C.J., Hopkins, S., Bell, K.C., Doña, J., Godfrey, S.S., Kwak, M.L., Lafferty, K.D., Moir, M.L., Speer, K.A., Strona, G. and Torchin, M. (2020). **A global parasite conservation plan**. *Biological Conservation*, 250:108596. https://doi.org/10.1016/j.biocon.2020.108596

Carscadden, K.A., Emery, N.C., Arnillas, C.A., Cadotte, M.W., Afkhami, M.E., Gravel, D., Livingstone, S.W. and Wiens, J.J. (2020). **Niche Breadth: causes and consequences for ecology, evolution, and conservation**. *The Quarterly Review of Biology*, 95(3):179-214. https://doi.org/10.1086/710388

Cheek, M., Nic Lughadha, E., Kirk, P., Lindon, H., Carretero, J., Looney, B., Douglas, B., Haelewaters, D., Gaya, E., Llewellyn, T. and Ainsworth, A.M. (2020). **New scientific discoveries: Plants and fungi**. *Plants, People, Planet*, 2(5):371-388. https://doi.org/10.1002/ppp3.10148

Cowley, K.L., Fryirs, K.A., Cohen, T.J., Marx, S., Forbes, M. and Krogh, M. (2020). **Upland peatlands of eastern Australia as important water storage reservoirs**. *Proceedings of the Linnean Society of New South Wales* **142**: 67-76. https://openjournals.library.sydney.edu.au/index.php/LIN/article/view/14815/13121

Cross, A.T., Krueger, T.A., Gonella, P.M., Robinson, A.S. and Fleischmann, A.S. (2020). **Conservation of carnivorous plants in the age of extinction**. *Global Ecology and Conservation*, p.e01272. https://doi.org/10.1016/j.gecco.2020.e01272

Dinerstein, E., Joshi, A.R., Vynne, C., Lee, A.T.L., Pharand-Deschênes, F., França, M., Fernando, S., Birch, T., Burkart, K., Asner, G.P. and Olson, D. (2020). **A "Global Safety Net" to reverse biodiversity loss and stabilize Earth's climate**. *Science advances*, 6(36):eabb2824. https://doi.org/10.1126/sciadv.abb2824

Dunstan, W.A., Howard, K., Grigg, A., Shaw, C., Burgess, T.I., and Hardy, G.E.S.J. (2020). **Towards eradication of *Phytophthora cinnamomi* using a fallow approach in a Mediterranean climate.** *Forests*, 11(10): 1101. https://doi.org/10.3390/f11101101

Garibaldi, L.A., Oddi, F.J., Miguez, F.E., Bartomeus, I., Orr, M.C., Jobbágy, E.G., Kremen, C., Schulte, L.A., Hughes, A.C., Bagnato, C. and Abramson, G. (2020). **Working landscapes need at least 20% native habitat.** *Conservation Letters*, e12773. https://doi.org/10.1111/conl.12773

Gallagher R.V. (2020). **National prioritisation of Australian plants affected by the 2019-2020 bushfire season** – Report to the Commonwealth Department of Agriculture, Water and Environment. https://www.environment.gov.au/biodiversity/bushfire-recovery/priority-plants

Gosper, C.R., Coates, D.J., Hopper, S.D., Byrne, M. and Yates, C.J. (2020). **The role of landscape history in the distribution and conservation of threatened flora in the Southwest Australian Floristic Region**. *Biological Journal of the Linnean Society*. https://doi.org/10.1093/biolinnean/blaa141

Hasler, O. (2020) **Mining as ecocide: The case of Adani and the Carmichael Mine in Australia**. In: Zabyelina, Y., van Uhm, D. (eds) *Illegal Mining*. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-46327-4_18

Heinen, J.H., Rahbek, C. and Borregaard, M.K. (2020). **Conservation of species interactions to achieve self-sustaining ecosystems**. *Ecography*. 43:1-9. https://doi.org/10.1111/ecog.04980

Irga, P.J., Dominici, L., and Torpy, F.R. (2020). **The mycological social network: a way forward for conservation of fungal biodiversity.** *Environmental Conservation*, 1-8. https://doi.org/10.1017/S0376892920000363

Khapugin, A.A. (2020). **A global systematic review on orchid data in protected areas**. *Nature Conservation Research*, 5(Suppl 1):19-33. https://dx.doi.org/10.24189/ncr.2020.019

Kirchhoff, C., Callaghan, C.T., Keith, D.A., Indiarto, D., Taseski, G., Ooi, M.K., Le Breton, T.D., Mesaglio, T., Kingsford, R.T. and Cornwell, W.K. (2020). **Rapidly mapping fire effects on biodiversity at a large-scale using citizen science**. *Science of The Total Environment*, 755(2):142348. https://doi.org/10.1016/j.scitotenv.2020.142348

Kotzé, J.D., Beukes, H.B. and Seifert, T. (2020). **Designing an optimal sampling strategy for a national level invasive alien plant assessment: A South African case study**. *Ecological Indicators*, 119:106763. https://doi.org/10.1016/j.ecolind.2020.106763

Liu, C., Wolter, C., Xian, W. and Jeschke, J.M. (2020). **Most invasive species largely conserve their climatic niche**. *Proceedings of the National Academy of Sciences*, 117(38):23643-23651. https://doi.org/10.1073/pnas.2004289117

Lughadha, E.N., Bachman, S.P., Leão, T.C., Forest, F., Halley, J.M., Moat, J., Acedo, C., Bacon, K.L., Brewer, R.F., Gâteblé, G. and Gonçalves, S.C. (2020). **Extinction risk and threats to plants and fungi.** *Plants, People, Planet*, 2(5):389-408. https://doi.org/10.1002/ppp3.10146

McDougall, K.L. and Liew, E.C.Y. (2020). **Quantifying the distribution and threat of *Phytophthora cinnamomi* in New South Wales: implications for its management in natural vegetation** *Cunninghamia*, 20: 153-181. https://doi.org/10.7751/cunninghamia.2020.20.008

Meadows, J., Annandale, M., Bristow, M., Jacobsen, R., Ota, L. and Read, S. (2020). **Developing Indigenous commercial forestry in northern Australia**. *Australian Forestry*. https://doi.org/10.1080/00049158.2020.1799518

Medd, R. (2020). **Distribution, ecology and conservation of the endangered shrub, *Acacia meiantha* (Fabaceae) in Central West New South Wales.** *Cunninghamia*, 20: 183-192. https://doi.org/10.7751/cunninghamia.2020.20.009

Mickaill, L.N., Bell, S.A. and Beranek, C.T. (2020). **Dispersal potential in two restricted and five wide-ranging *Senecio* (Asteraceae) taxa from central eastern New South Wales, Australia.** *Australian Journal of Botany*. https://doi.org/10.1071/BT20015

Millar, M.A. and Byrne, M. (2020). **Variable clonality and genetic structure among disjunct populations of *Banksia mimica***. *Conservation Genetics*, 21(5):803-818. https://doi.org/10.1007/s10592-020-01288-0

Mogilski, M., Fensham, R. and Firn, J. (2020). **Effects of local environmental heterogeneity and provenance selection on two direct seeded eucalypt forest species.** *Restoration Ecology*. https://doi.org/10.1111/rec.13255

Paap, T., Wingfield, M.J., Burgess, T.I., Hulbert, J.M. and Santini, A. (2020). **Harmonising the fields of invasion science and forest pathology**. *NeoBiota*, 62: 301-322. https://doi.org/10.3897/neobiota.62.52991

Pastur, G.J.M., Rosas, Y.M., Cellini, J.M., Barrera, M.D., Manríquez, M.D.T., Herrera, A.H., Bondar, S.F., Lencinas, M.V. and Peri, P.L. (2020). **Conservation values of understory vascular plants in even-and uneven-aged *Nothofagus antarctica* forests.** *Biodiversity and Conservation*, 29(13):3783-3805. https://doi.org/10.1007/s10531-020-02049-8

Pence, V.C., Ballesteros, D., Walters, C., Reed, B.M., Philpott, M., Dixon, K.W., Pritchard, H.W., Culley, T.M. and Vanhove, A.C. (2020). **Cryobiotechnologies: tools for expanding long-term *ex situ* conservation to all plant species.** *Biological Conservation*, 250:108736. https://doi.org/10.1016/j.biocon.2020.108736

Pérez H., Hill L.M. and Walters C. (2020). **A protective role for accumulated dry matter reserves in seeds during desiccation: implications for conservation**. In: Chong P., Newman D., Steinmacher D. (eds) *Agricultural, Forestry and Bioindustry Biotechnology and Biodiscovery*. Springer, Cham. https://doi.org/10.1007/978-3-030-51358-0_8.

Pommerening, A., Brill, M., Schmidt-Kraepelin, U. and Haufe, J. (2020). **Democratising forest management: Applying multiwinner approval voting to tree selection**. *Forest Ecology and Management*, 478:118509. https://doi.org/10.1016/j.foreco.2020.118509

Raza A., Charagh S., Razzaq A., Javed R., Khan R.S.A. and Hasanuzzaman M. (2020) **Brassicaceae plants response and tolerance to drought stress: physiological and molecular interventions**. In: Hasanuzzaman M. (eds) *The Plant Family Brassicaceae*. Springer, Singapore. https://doi.org/10.1007/978-981-15-6345-4_7

Reiter, N., Phillips, R. D., Swarts, N. D., Wright, M., Holmes, G., Sussmilch, F. C., Davis, B.J., Whitehead, M.R. and Linde, C. C. (2020). **Specific mycorrhizal associations involving the same fungal taxa in common and threatened *Caladenia* (Orchidaceae): implications for conservation**. *Annals of botany*, 126(5): 943-955. https://doi.org/10.1093/aob/mcaa116

Rennie, S.J. (2020). **Small changes to avoid major loss: collaborative conservation practices at Rouse Hill House and Farm**. *Studies in Conservation*, 65(supp 1):1-6. https://doi.org/10.1080/00393630.2020.1789390

Robins, T.P., Binks, R.M., Byrne, M. and Hopper, S.D. (2020). **Contrasting patterns of population divergence on young and old landscapes in *Banksia seminuda* (Proteaceae), with evidence for recognition of subspecies.** *Biological Journal of the Linnean Society*. https://doi.org/10.1093/biolinnean/blaa098

Rosner-Katz, H., McCune, J.L. and Bennett, J.R. (2020). **Using stacked SDMs with accuracy and rarity weighting to optimize surveys for rare plant species**. *Biodiversity and Conservation*, 29(11):3209-3225. https://doi.org/10.1007/s10531-020-02018-1

Salman, M.M., Kharroubi, S., Itani, M. and Talhouk, S.N. (2020). **Using IUCN protected areas management categories as a tool to assess youth preferences for local management of an Important Plant Area (IPA) in Lebanon**. *Land Use Policy*, 99:105035. https://doi.org/10.1016/j.landusepol.2020.105035

Sandiford, P.J. and Green, S. (2020). **'It's my passion and not really like work': Balancing precarity with the work–life of a volunteer team leader in the conservation sector**. Work, Employment and Society, 00:1-11. https://doi.org/10.1177/0950017020942052

Shackleton, R.T., Bertzky, B., Wood, L.E., Bunbury, N., Jäger, H., van Merm, R., Sevilla, C., Smith, K., Wilson, J.R., Witt, A.B. and Richardson, D.M. (2020). **Biological invasions in World Heritage Sites: current status and a proposed monitoring and reporting framework**. *Biodiversity and Conservation*, 29(11):3327-3347. https://doi.org/10.1007/s10531-020-02026-1

Sommerville, K. (2020) **The Rainforest Seed Conservation Project**. *Royal Botanic Gardens Sydney Virtual Science Seminars*. https://www.rbgsyd.nsw.gov.au/Science/Virtual-science-seminars/The-Rainforest-Seed-Conservation-Project

Tabassum, S., Ossola, A., Manea, A., Cinantya, A., Winzer, L.F. and Leishman, M.R. (2020). **Using ecological knowledge for landscaping with plants in cities**. *Ecological Engineering*, 158:106049. https://doi.org/10.1016/j.ecoleng.2020.106049

Thomson, J., Regan, T.J., Hollings, T., Amos, N., Geary, W.L., Parkes, D., Hauser, C.E. and White, M. (2020). **Spatial conservation action planning in heterogenous landscapes**. *Biological Conservation*, 250:108735. https://doi.org/10.1016/j.biocon.2020.108735

Thorn, S., Chao, A., Georgiev, K.B., Müller, J., Bässler, C., Campbell, J.L., Castro, J., Chen, Y.H., Choi, C.Y., Cobb, T.P. and Donato, D.C. (2020). **Estimating retention benchmarks for salvage logging to protect biodiversity.** *Nature Communications*, 11(1):1-8. https://doi.org/10.1038/s41467-020-18612-4

Tingstad, L., Grytnes, J.A., Sætersdal, M. and Gjerde, I. (2020). **Using Red List species in designating protection status to forest areas: a case study on the problem of spatio-temporal dynamics**. *Biodiversity and Conservation*, 29(11):3429-3443. https://doi.org/10.1007/s10531-020-02031-4

Tisdell, C. A., Auld, B. A., and Johnson, S. B. (2020). **Models and strategies for prioritizing the control of invasive exotic weeds in protected areas: theoretical and pragmatic challenges**. In *Environmental Assessments*. Cheltenham, UK: Edward Elgar Publishing. https://doi.org/10.4337/9781788976879.00017

Török, P., Bullock, J.M., Jiménez-Alfaro, B. and Sonkoly, J. (2020). **The importance of dispersal and species establishment in vegetation dynamics and resilience**. *Journal of Vegetation Science*. 00:1-8, https://doi.org/10.1111/jvs.12958

Trezise, J. E., Facelli, J. M., Paton, D. C. and J.-P. Davies, R. (2020) **The effect of heat and smoke on the soil seed banks of heathlands on permanent freshwater swamps.** *Austral Ecology*. https://doi.org/10.1111/aec.12957

Valentine, L.E., Ramalho, C.E., Mata, L., Craig, M.D., Kennedy, P.L. and Hobbs, R.J. (2020). **Novel resources: opportunities for and risks to species conservation**. *Frontiers in Ecology and the Environment*. https://doi.org/10.1002/fee.2255

White, L., Catterall, C., and Taffs, K. (2020) **Fire can promote germination, recruitment and seed bank accumulation of the threatened annual grass *Arthraxon hispidus*.** *Australian Journal of Botany,* https://doi.org/10.1071/BT20004

White, L., Catterall, C., Wirf, B. and Taffs, K. (2020). **Waterlogging tolerance of the threatened grass *Arthraxon hispidus* and implications for its habitat niche within endangered wetlands in north-eastern New South Wales.** *Pacific Conservation Biology*. https://doi.org/10.1071/PC20044

White, R. (2020) **Eco-Justice and Destructive Mining in Australia: Lessons from the New South Wales Land and Environmental Court**. In: Zabyelina, Y., van Uhm, D. (eds) *Illegal Mining*. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-46327-4_19

Wildlife and threatened species bushfire recovery expert panel (2020). **Final list of plants requiring urgent management intervention** – Report to the Commonwealth Department of Agriculture, Water and Environment. https://www.environment.gov.au/biodiversity/bushfire-recovery/priority-plants

Wilson, J.R., Bacher, S., Daehler, C.C., Groom, Q.J., Kumschick, S., Lockwood, J.L., Robinson, T.B., Zengeya, T.A. and Richardson, D.M. (2020). **Frameworks used in invasion science: progress and prospects.** *NeoBiota*, 62:1-30. https://doi.org/10.3897/neobiota.62.58738

Young, K.R. and Duchicela, S. (2020). **Abandoning holocene dreams: proactive biodiversity conservation in a changing world**. *Annals of the American Association of Geographers,* https://doi.org/10.1080/24694452.2020.1785833

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